PROCEEDINGS

Lake States Forest Genetics Conference . .

MARCH 31 – APRIL 1, 1953

Miscellaneous Report No. 22

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE – FOREST SERVICE

FOREWORD

Over the years there has been a small but important amount of research in forest genetics in the Lake States, and recently there has been a growing awareness of the importance of tree improvement in this region. For these reasons it appeared that a meeting of people active or interested in forest genetics might be worth while. So after consultation with a number of foresters and geneticists in Minnesota, Wisconsin, and Michigan, we decided to sponsor a Lake States Forest Genetics Conference at Eagle River, Wisconsin, on March 31 and April 1, 1953.

This Conference provided an opportunity (1) for those engaged in forest genetics research to report briefly on what they have done and what they have learned, (2) for those interested to learn the status of such research in the Lake States, and (3) for interested people to point out problems needing study. Out of this Conference there developed the Lake States Forest Tree Improvement Committee, the purpose of which is to "encourage and coordinate forest genetics activities in this region." This, I believe, represents a forward step of far-reaching importance.

I should like to express my appreciation to all who participated in this Conference. Special thanks are due Dr. Ernest B. Babcock of the Forest Genetics Research Foundation, Dr. Scott S. Pauley of Harvard University, and Dr. C. Heimburger of the Ontario Department of Lands and Forests, who came long distances to meet with us, and to M. N. Taylor and his staff at Trees for Tomorrow, Inc., for the excellent meeting place and facilities they made available to us.

M. B. DICKERMAN
Director, Lake States Forest
Experiment Station

LAKE STATES FOREST GENETICS CONFERENCE

PROGRAM AND TABLE OF CONTENTS

Sponsor: Lake States Forest Experiment Station
Place: Trees for Tomorrow Camp, Eagle River, Wis.

March 31, 9:00 a.m.

Forest Genetics in the Lake States - Past and Present

Chairman: S. A. Graham, University of Michigan

March 31, 2:45 p.m.

Forest Genetics in Other Regions

Chairman: D. P. Duncan, University of Minnesota

April 1, 8:30 a.m.

Forest Genetics Problems Needing Study

Chairman: R. A. Brink, University of Wisconsin

Panel discussion on growing more productive trees:

FOREST GENETICS WORK AT THE LAKE STATES FOREST EXPERIMENT STATION[1] *

Paul O. Rudolf[2]

Almost from its inception the Lake States Forest Experiment Station showed an awareness of the importance of forest genetics. In 1928, only five years after its establishment, the Station began a study of red pine seed sources. This study, planned by the late Carlos G. Bates, was followed by other seed source projects concerning Scotch pine, Norway spruce, white spruce, green ash, ponderosa pine, European larch, and jack pine. In addition, a number of exotic forest trees have been planted to test their adaptability to this region. Except for an attempt with sugar maple in 1928, the Station's tree breeding program has been confined to field-testing of poplar and pine hybrids developed elsewhere.

SEED SOURCE STUDIES

Red Pine

Because of its valuable wood properties, hardiness, relative freedom from insect pests and diseases, and adaptability to sandy soils, red pine (*Pinus resinosa*) was, and has remained, the most widely planted forest tree species in the Lake States. However, stands suitable and readily available for seed collection were somewhat limited. It was logical, therefore, that the first genetics project of the Station was a study to determine how much racial variation there might be in red pine. Three groups of plantings were made.

Prior to any field planting, laboratory tests of cold resistance were made on 1-0 seedlings of 30 seed sources in the fall of 1929. Trees were hardened at 0°C. for one week and then held at -6.5°C. for one day. Results showed in general that seedlings of northern origin adjusted themselves to low temperatures better than those of more southern origin.

In 1931, red pine stock of 39 Lake States and 2 New England origins was field-planted on the Superior and Chippewa National Forests in Minnesota and the Huron National Forest in Lower Michigan.

In 1933, stock of 146 Lake States, 4 Northeastern, and 4 Ontario localities was planted in the same three localities.

1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota.

2/ Forester, Lake States Forest Experiment Station.

* Titles marked by an asterisk represent papers which have been condensed to some degree over the presentation given at the Conference.

The drought of 1936 largely eliminated the Chippewa and Huron plantings, but those on the Superior came through with only light (1931) to moderate (1933) mortality.

An analysis of results from the 1931 planting, when the trees were 16 years old (from seed), indicated that the best lots were from northeastern Minnesota, with some from northwestern Minnesota, north-central Minnesota, and northeastern Wisconsin nearly as good. Lots from New England, Lower Michigan, central Wisconsin, and northwestern Wisconsin did not show up so well.

In 1937, stock of 51 red pine seed sources from the Lake States and the Northeast was planted on the Chippewa National Forest. At the end of 14 growing seasons in the field, growth had been generally excellent and there appeared to be no striking differences between sources. Stock of the same lots was planted in northwestern Pennsylvania at the same time. Distinct differences between sources were reported in Station Paper No. 49 of the Northeastern Forest Experiment Station.

General

Increasingly valuable results should be forthcoming from these plantations as the trees grow older and have more opportunities to express their adaptation to the environment of the planting site.

Scotch Pine

Scotch pine (*Pinus sylvestris*) was one of the first forest trees planted in the Lake States, probably because it was familiar to European immigrants and because nursery stock was available. Because many of the plantings did not develop satisfactorily, a study of seed sources seemed advisable. The Station made three groups of plantings including a number of seed sources.

In 1931, Scotch pine stock of 20 origins, representing both northern and central European types, was planted on the Superior and Chippewa National Forests in Minnesota and the Huron National Forest in Lower Michigan.

In 1933, stock of 8 additional sources was planted in these same localities.

Drought and fire destroyed the Chippewa and Huron plantations leaving only that on the Superior National Forest for continued observation. Up to 19 years from seed, there had been marked differences between sources with the more rapid growth of central European sources offsetting their poorer form. However, during the winter of 1947-48, the Scotch pines of central European origin were injured much more severely than those from northern European or Asiatic sources. Many succumbed to this injury.

In 1937, stock of 24 seed sources of Scotch pine was planted on a good site on the Chippewa National Forest. Nineteen of these lots were of central European origin; they were severely damaged during the winter of 1947-48.

In 1941, Scotch pine stock from 10 European sources, received from the International Union of Forest Research Organizations, was field-planted on the Chippewa National Forest in Minnesota and the Manistee National Forest in Lower Michigan.

On the Chippewa National Forest, the winter of 1947-48 caused severe damage to those sources which originated in areas of milder climate than the Chippewa. On the other hand, those sources which came from climatic zones similar to the Chippewa suffered little or no damage. On the Manistee National Forest, severe winter conditions were not experienced and Scotch pine survivals were good — better than native red pine planted as a check. Height growth also was better than for red pine but varied considerably according to source at the end of 11 years in the field (13 years from seed). Except for one source from Finland and one from Romania, however, all Scotch pine lots had been heavily attacked by the white pine weevil.

General

In the Lake States, Scotch pine of a number of sources has suffered so much injury and mortality from climatic and biotic factors that its general use as a forest tree cannot be recommended. Since it does have some value for special purposes (Christmas tree production, sand blow planting, etc.) and possibly for growing in southern parts of the Lake States where the European pine shoot moth limits the use of red pine, some search should be continued for hardy races of good growth characteristics.

Ponderosa Pine

Because of its drought resistance, ponderosa pine is probably the best pine for planting in the prairie-plains region. Its wide natural range makes it certain that ponderosa pine has developed a number of races. It is important to learn which races are best for various localities.

Ponderosa pines (*Pinus ponderosa*) grown from seed originating in western North Dakota, eastern Montana, western Nebraska, and the Black Hills of South Dakota, were planted on a sandhills area in north-central North Dakota in the spring of 1940. Differences in growth between sources are not great, but there have been distinct differences in amount of winter foliage injury. The nearest-native sources, western North Dakota and eastern Montana, have had distinctly less injury than the Black Hills and western Nebraska sources.

Jack Pine

Primarily because of its rapid early growth, its use for pulpwood, and its suitability for rather poor sandy soils, jack pine has been planted extensively in the Lake States and probably will continue to be planted widely. To help guide future plantings the Station has undertaken some seed source and age of mother tree studies.

In 1937, jack pine stock of three Minnesota sources and one Lower Michigan source was planted on the Chippewa National Forest adjacent to red pine plantings. Early differences between sources were insignificant and no recent appraisals are available.

In 1937, on the Huron National Forest in Michigan, the Station planted jack pine grown from seed gathered from trees within the same stand which were 1-10, 11-20, 21-40, 41-60, and 61+ years old. In 1939, the Huron National Forest planted jack pine grown from seeds collected from trees aged 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, and 71-80 years. Although there was a general tendency for the oldest age classes to produce smaller cones and smaller seeds than those which were younger, little difference was apparent in the nursery stock they produced. At the end of 10 and 14 years from seed, plantations of this stock displayed no significant differences attributable to age of mother tree.

In 1943, jack pine stock of nine seed origins (four from Wisconsin, four from Michigan, and one from northern Indiana) was planted on the Manistee National Forest. At the age of 10 years from seed (all favorable growing seasons) there were no distinct differences between sources in survival, growth, or susceptibility to weevil attack.

Currently under way is a jack pine seed source study in cooperation with the University of Minnesota, the Conservation Departments of Wisconsin, Minnesota, and Michigan, and some industries. This includes 29 seed collections in the three Lake States, each representing a stand considered good for that locality. One-year-old stock now is in the State nurseries at Rhinelander, Wisconsin and Willow River, Minnesota. Field plots will be set out in several localities in each State in the spring of 1954.

Spruces

Spruces are premium pulpwood trees and there is increasing interest in planting them. It is advisable to know how far afield it is safe to go in obtaining seed, and whether any of the exotics are suitable for this region. For these reasons, the Station has undertaken two sets of tests concerning spruce seed sources.

In 1936, the Station planted stock of nine spruces, as follows: white spruce (*Picea glauca*), six sources from the Lake States and Ontario; Norway spruce (*P. abies*), six sources, mostly from the U.S.S.R.; red spruce (*P. rubens*), two sources from Pennsylvania and North Carolina; black spruce (*P. mariana*) from the Chippewa National Forest, Minnesota; western white spruce (*P. glauca* var. *albertiana*) from South Dakota; Sakhalin spruce (*P. glehnii*) from northern Japan; oriental spruce (*P. orientalis*) from the Caucasus region; and Serbian spruce (*P. omorika*) from Jugoslavia. Plantings were made on the Nicolet National Forest in northeastern Wisconsin, the Superior and Chippewa National Forests in northern Minnesota, the Hiawatha National Forest in Upper Michigan, and

In 1937, jack pine stock of three Minnesota sources and one Lower Michigan source was planted on the Chippewa National Forest adjacent to red pine plantings. Early differences between sources were insignificant and no recent appraisals are available.

In 1937, on the Huron National Forest in Michigan, the Station planted jack pine grown from seed gathered from trees within the same stand which were 1-10, 11-20, 21-40, 41-60, and 61+ years old. In 1939, the Huron National Forest planted jack pine grown from seeds collected from trees aged 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, and 71-80 years. Although there was a general tendency for the oldest age classes to produce smaller cones and smaller seeds than those which were younger, little difference was apparent in the nursery stock they produced. At the end of 10 and 14 years from seed, plantations of this stock displayed no significant differences attributable to age of mother tree.

In 1943, jack pine stock of nine seed origins (four from Wisconsin, four from Michigan, and one from northern Indiana) was planted on the Manistee National Forest. At the age of 10 years from seed (all favorable growing seasons) there were no distinct differences between sources in survival, growth, or susceptibility to weevil attack.

Currently under way is a jack pine seed source study in cooperation with the University of Minnesota, the Conservation Departments of Wisconsin, Minnesota, and Michigan, and some industries. This includes 29 seed collections in the three Lake States, each representing a stand considered good for that locality. One-year-old stock now is in the State nurseries at Rhinelander, Wisconsin and Willow River, Minnesota. Field plots will be set out in several localities in each State in the spring of 1954.

Spruces

Spruces are premium pulpwood trees and there is increasing interest in planting them. It is advisable to know how far afield it is safe to go in obtaining seed, and whether any of the exotics are suitable for this region. For these reasons, the Station has undertaken two sets of tests concerning spruce seed sources.

In 1936, the Station planted stock of nine spruces, as follows: white spruce (*Picea glauca*), six sources from the Lake States and Ontario; Norway spruce (*P. abies*), six sources, mostly from the U.S.S.R.; red spruce (*P. rubens*), two sources from Pennsylvania and North Carolina; black spruce (*P. mariana*) from the Chippewa National Forest, Minnesota; western white spruce (*P. glauca* var. *albertiana*) from South Dakota; Sakhalin spruce (*P. glehnii*) from northern Japan; oriental spruce (*P. orientalis*) from the Caucasus region; and Serbian spruce (*P. omorika*) from Jugoslavia. Plantings were made on the Nicolet National Forest in northeastern Wisconsin, the Superior and Chippewa National Forests in northern Minnesota, the Hiawatha National Forest in Upper Michigan, and

the Huron National Forest in Lower Michigan. The severe drought and heat conditions during the summer of 1936 largely eliminated the plantings on the Chippewa, Hiawatha and Huron National Forests and caused considerable mortality in the Superior National Forest planting. That on the Nicolet escaped with relatively light injury, largely because it was protected by an aspen overstory.

The Nicolet planting has demonstrated the unsuitability of the red, Sakhalin, Serbian and oriental spruces for this locality and some distinct differences in growth, survival, and hardiness among the several sources of white and Norway spruces. The unfavorable winter of 1947-48 caused no damage to western white spruce, and northern sources of white spruce. All Norway spruces suffered more needle damage than any of the white spruces, but trees of northern sources suffered less than those from milder climates. In spite of severe defoliation, however, there was little or no mortality in any lots. Fifteen years after planting, the white spruces generally looked better than any other species. Some Norway spruce lots have done quite well, although weevil injury is becoming more general among them.

In 1941, stock of 12 European sources of Norway spruce, received from the International Union of Forest Research Organizations, was field-planted on the Chippewa National Forest in Minnesota and the Manistee National Forest in Lower Michigan. Sources ranged from Norway south to Switzerland and east to Jugoslavia, Romania, and Poland.

During the open winter of 1943-44 most of the lots on the Chippewa National Forest suffered serious mortality. Those planted on the Manistee had survived better and suffered less weevil damage after 11 years in the field than white pines (*Pinus strobus*) grown with them as check lots. Their growth was less than that of the pine, although two lots were about equal in height to associated white pine.

European Larch

European larch makes very rapid growth in its homeland and in some parts of the eastern United States. It has been planted on farms in the southern Lake States, but information on variations traceable to seed origin has been lacking. To obtain some information on racial variation of this species, stock of 11 sources of European larch (*Larix decidua*) and one source of Siberian larch (*L. sibirica*) (grown from seed furnished by the International Union of Forest Research Organizations) was field-planted as 2-1 transplants in the spring of 1949 on the Chippewa National Forest in Minnesota, Nicolet National Forest in Wisconsin, and in Kent County in Lower Michigan. Check lots of native tamarack (*Larix laricina*) were planted in each block.

Unfortunately, the stock was injured in shipment, so that mortality was severe in Lower Michigan, moderately heavy in Wisconsin, and moderate in Minnesota. In view of this circumstance and the short time since planting, results are not yet available.

Green Ash

In 1934, green ash (*Fraxinus pennsylvanica* var. *lanceolata*) seed was collected from 83 trees in 39 localities of North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, and Oklahoma. In 1935 and 1936, laboratory tests showed that seed from the northwest part of the region produced the most drought resistant plants, while southern and eastern seed produced those least drought resistant.

Stock grown from these seed collections in two nurseries (one in North Dakota and one in Nebraska) exhibited variations as follows: seed from northern areas germinated more slowly and produced stock which was smaller, had smaller, darker green leaves, and grew for a shorter period than did stock from southern areas. Winter damage in the North Dakota nursery increased almost directly with the southerliness of seed origin. Unfortunately, field plantings of this stock were damaged so that valid follow-up results were not available.

TESTS OF EXOTIC SPECIES

In addition to the seed source projects, the Station since the 1920's has tested over 100 tree species native to Europe, Asia, and other regions of North America, in addition to those included in provenience tests. Those which have the ability to grow under Lake States conditions may have some value in future breeding programs.

The following 60 species have been planted: Austrian, Balkan, Bosnian, Chinese, Corsican, Japanese black, Japanese red, Japanese stone, Japanese white, Korean, limber, lodgepole, pinyon, pitch, Siberian stone, table mountain, western white, whitebark, and Virginia pines; blue, Engelmann, Maximowicz, and Schrenk spruces; Dahurian, Japanese, Korean, and Siberian larches; alpine, Manchurian, Maries, and momi firs; Chinese, Mexican, oneseed, Rocky Mountain, and Utah junipers; oriental arborvitae, baldcypress, bigtree, Douglasfir, European speckled alder; Altai, Asian, white, Dahurian, European white, and Schmidts birches; Russian, Scotch, and Siberian elms; Manchurian linden; Amur and Norway maples; European mountainash, Russian mulberry, osage-orange, Russian-olive, Amur tamarix, Persian walnut, and golden willow. Several other species proved unsuitable in the nursery and were not field-planted.

TREE BREEDING

Tree breeding probably represents one of the greatest opportunities for increasing the productivity of our forests. To be successful, tree breeding must be based on (1) a good understanding of variation within species, and the extent to which it is heritable, and (2) the participation of trained geneticists. Neither were available in the early days of the Station's work.

Sugar Maple

In 1928, an attempt was made at the Upper Peninsula branch to cross-pollinate between bird's-eye maples and at the Forest Products Laboratory in Madison to graft on root cuttings from such trees. Both efforts failed. Seed collected in the fall of 1928 from trees having high and low chances of carrying any hereditary bird's-eye factors were sown at the Upper Peninsula branch, but largely failed to germinate. A large number of cuttings were made in 1929, but the grafting method employed at Madison was unsuccessful. Some observations indicated that the bird's-eye character was closely associated with suppression of young seedlings. The hereditary nature of this character, however, was neither proved nor disproved.

Hybrid Poplars

Because poplars produce wood useful for a number of products, are rapid growing, and many are relatively easy to propagate from cuttings and to hybridize, they have been widely used in tree breeding work. Beginning in 1924, the Oxford Paper Company of Rumford, Maine, in cooperation with the New York Botanical Garden, developed hybrid poplars representing combinations between 34 different species, varieties, and hybrids. Cuttings of 30 clones were sent to the Lake States Station, and field tests were made between 1935 and 1940 in several localities in Michigan, Wisconsin, Minnesota, and North Dakota.

Most of the hybrids grew 5 to 7 feet tall the first year in the nursery, and about 3 feet more when they were left for a second year. Growth was less in the field, averaging about 3 feet per year for the best conditions — good soil, complete ground preparation, and thorough cultivation the first few years. Under other conditions growth was poor. By the end of 10 years those clones which had shown climatic adaptability either had succumbed to or were on the way out from cankers.

All these hybrids were developed from black poplars and balsam poplars and none from species native to the Lake States. Hardy, fast-growing hybrids doubtless can be developed from other species.

Hybrid Pines

Pines in general are among our most valuable timber trees. Possibilities of increasing their productivity and hardiness through breeding are under investigation at the Institute of Forest Genetics, Placerville, California.

Early in 1950 the Institute sent seed of 10 hybrids to the Lake States Station. Included were 5 hybrids of western white pine (*Pinus monticola*) and eastern white pine (*P. strobus*) and 5 hybrids of lodgepole pine (*P. contorta* var. *latifolia*) and jack pine (*P. banksiana*). Stock of the latter hybrids grown in the Hugo Sauer Nursery at Rhinelander will be planted in three localities (one each in Michigan, Wisconsin, and Minnesota) in the spring of 1953. Stock of the parent species, including one of local origin, will be planted along with the hybrids. Stock of the white pine hybrids will be planted in 1954.

AN EVALUATION

Since its establishment the Lake States Forest Experiment Station has made seed source studies of eight forest tree species and field tests of about a score of exotic tree species. It made some early attempts at breeding sugar maple, has field-planted stock of 31 hybrid poplars, and has stock of 10 hybrid pines in the nursery in preparation for field testing.

In view of the immense amount of work needed in forest genetics these studies do not loom large. Yet they have already made some contributions, and because of their long-time nature will yield more. They have demonstrated racial variation in red pine, Scotch pine, ponderosa pine, white spruce, Norway spruce, and green ash. They have also illustrated the unsuitability of a number of hybrid poplars for this region. Results have emphasized the need for replication of field tests in a number of localities to avoid unpredictable losses. Finally, these studies have pointed to the need for a great deal more research in forest genetics in the Lake States.

PUBLICATIONS OF THE LAKE STATES FOREST EXPERIMENT STATION IN THE FIELD OF FOREST GENETICS

Bates, C. G.
1928. Tree seed farms. Jour. For. 26(8): 969-976.

________ 1929. Some problems of seed production, collection, and distribution. For. Chron. 5(1): 17-29.

________ 1930. The frost hardiness of geographic strains of Norway pine. Jour. For. 28(3): 327-333.

________ 1931. A new principle in seed collecting for Norway pine. Jour. For. 29(5): 661-678.

Lake States Forest Experiment Station
1928. Climatic seed sources for Norway pine. Tech. Note No. 5, 1 p., mimeo.

________ 1929. Why nurserymen prefer southern seeds. Tech. Note No. 19, 1 p., mimeo. Also: Jour. For. 28(2): 232-233.

________ 1930. Frost hardiness of races of Norway pine seedlings. Tech. Note No. 22, 1 p., mimeo.

________ 1931. Centers for collecting Norway pine. Tech. Note No. 30, 2 pp., mimeo.

____
1937. Seed origin affects survival of green ash in the nursery. Tech. Note No. 128, 1 p., mimeo.

____
1939. A fast-growing and winter-hardy poplar hybrid still to be found for the Lake States. Tech. Note No. 153, 1 p., mimeo.

Meuli, L. J.
1936. Drought resistance of green ash as affected by geographic origin. Proc. Minn. Acad. Sci. 4: 38-42.

__________ and Shirley, H. L.
1937. The effect of seed origin on drought resistance of green ash in the Prairie-Plains States. Jour. For. 35(11): 1060-1062.

Ralston, R. A.
1951. Is jack pine tree growth affected by age of parent tree? Tech. Note No. 358, 1 p., mimeo. Also: Timber Prod. Bull. (Duluth) 7(12): 11. Aug. 1952.

Rudolf, Paul O.
1936. Pedigreed trees. Minn. Cons. 37: 4-5.

____
1947. Importance of red pine seed source. Proc. S.A.F. meeting, Dec. 17-20, 1947: 384-398.

____
1948. Local red pine develops best plantations. Tech. Note No. 296, 2 pp., mimeo.

____
1948. Winter damage to Scotch pine in northern Minnesota. Tech. Note No. 305, 1 p., mimeo.

____
1948. Hybrid poplar planting in the Lake States. Sta. Paper No. 14, 17 pp., mimeo.

____
1950. Scotch pine seed sources for northeastern Minnesota. Proc. Minn. Acad. Sci. 16(1948): 25-26.

____
1950. Variation in Scotch pine. Papers Mich. Acad. Sci., Arts & Letters 34(1948): 57-68.

____
1951. Winter damage and seed source of planted pines in northern Minnesota. Proc. Minn. Acad. Sci. 17(1949): 74-79.

______ 1951. Nursery behavior of red pine stock of different seed origins. USDA, Forest Service, Tree Planters' Notes, No. 8, pp. 3-4.

______ and Ralston, R. A.
1953. Do age of mother tree and age of cone affect development of young jack pine? Jour. For. 51(2): 121-124.

Shirley, Hardy L.
1937. The relation of drought and cold resistance to source of seed stock. Minn. Horticulturist. Feb.

Stoeckeler, J. H., and Rudolf, Paul O.
1949. Winter injury and recovery of conifers in the upper Midwest. Sta. Paper No. 18, 20 pp., mimeo.

DEVELOPING DISEASE-RESISTANT TREES AT THE UNIVERSITY OF WISCONSIN*

A. J. Riker[1]

In Wisconsin, the State Conservation Department and the U. S. Forest Service already have shown distinguished leadership in reforestation and improved silviculture. They have made important and extensive efforts to restore the natural resources provided by trees. Thus, they have attached a destiny to much otherwise useless land.

To assist with certain phases of this work, the College of Agriculture has been breeding forest trees for disease resistance since 1935.

Three erroneous criticisms sometimes have been made against tree breeding, namely: it rivals silviculture, it takes too long, and it costs too much. Let us consider each one briefly.

Actually, tree breeding is an adjunct to and supplements silviculture. The process of cutting the best trees and leaving the scrubs for seed trees leads to eventual degeneration. A sound tree improvement program should employ sound silvicultural practices which would eliminate such decline.

Things that take a long time must be started at once. However, the time required to synthesize and to use improved varieties is not nearly so long as often thought. Vegetative propagation and better breeding techniques permit results in a relatively short time.

1/ Professor, Department of Plant Pathology, University of Wisconsin.

(This paper was illustrated by kodachrome slides.)

Tree breeding is expensive, of course, like most long-time research. However, one should consider the overall cost in terms of possible return in the form of industrial development, employment, and maximum land use. Then tree breeding becomes a "must" item with a high priority.

The basic procedures for breeding trees are relatively simple. They have been developed and proved with many agricultural crops. They include: (1) selection of outstanding individuals already present, followed by thorough testing and screening for desirable characteristics of superior native trees; (2) similar critical selection and examination of related trees grown elsewhere that have shown unusually desirable characteristics; (3) additional improvement by cross-pollinating trees with the best characteristics and by giving thorough tests to the seedling progeny.

In pathology, we have been particularly concerned with developing trees for disease resistance. The reason we have done this work is because the genetics involved is simple, while the pathology is relatively complex.

Work at the College of Agriculture has been in cooperation with many different agencies, including particularly the Wisconsin Conservation Department, the United States and State Departments of Agriculture, and various forest industries, especially the Nekoosa-Edwards Paper Company. In our work to develop white pine resistant to blister rust, Messrs. W. H. Brener, T. F. Kouba, and R. F. Patton have had active participation. In our work with poplars resistant to canker, rust, and so on, Messrs. J. E. Kuntz and K. R. Shea have been particularly active.

Frequently, difficult and complex questions arise in connection with any work of this kind. Success through tree breeding depends on coordinated cooperation of many different agencies over a long period of time. We feel that our progress would have been practically impossible without an opportunity frequently to consult our colleagues in the Departments of Biochemistry, Engineering, Entomology, Genetics, Soils, Wild Life Management, and so on. Likewise, we have secured much helpful advice from professional men in the Forest Products Laboratory and in the State Conservation Department.

To make very short a 15-year story of developing rust-resistant white pine, we originally selected 163 trees and since then have accumulated over 60 additional selections. If I could take you to the Blister Rust Nursery at Wisconsin Rapids, I would show you a number of trees which have survived extremely severe epidemics of blister rust infection. The early work is described in the Journal of Forestry 41: 753-760, 1943. Further work has confirmed and extended these studies. Among the first 163 trees, we have approximately 3 dozen which possess a high degree of resistance to the blister rust fungus and which give promise of surviving in many areas where the eradication of Ribes bushes is not feasible.

Obviously, breeding these resistant trees is not in competition with the Ribes eradication program. Rather, our work supplements Ribes control in this way: On approximately half of the white pine sites in Wisconsin,

Ribes eradication is not feasible for one reason or another. Rust-resistant pines appear to be the only answer.

Our work on poplars was begun in 1938 under a stimulus from Dr. Raphael Zon. He pointed out that more raw cellulose could be secured from the right kind of poplars in a suitable location than from any other species.

Recently, poplars have received increasing attention because of improvements in various technical processes that permit greater utilization of wood from this common and widely distributed species. Production, however, is seriously limited by disease, particularly by Hypoxylon canker. This disease has infected large numbers of trees and has made certain investments go bad that originally appeared foolproof.

Some widely touted hybrid poplars developed elsewhere have been unsatisfactory in Wisconsin because of their susceptibility to cankers, especially those caused by Septoria and Cytospora. However, these poplars have shown a relatively high degree of resistance to Hypoxylon canker.

Our work in Wisconsin has been directed primarily toward selecting the best poplar trees of the native species. Also we have secured elite trees from elsewhere. For several years we have been making crosses between the most promising selections so as to combine the better and to eliminate the poorer characteristics, including disease susceptibility.

So far, we have collected from one source or another over 400 selections which are being tested in various places. We have greatest hope from trees that have already grown well in Wisconsin and have demonstrated their ability to withstand Wisconsin weather, insects, and disease. Doubtless considerably improved trees can be secured by crossing such desirable parents.

The techniques for making cross-pollinations are easy. However, in handling pollen, seed, and seedlings, we have encountered numerous obstacles. Recent experiments have overcome important difficulties. We now feel confident that we have overcome the important ones and that we are ready to move forward as rapidly as our facilities and personnel will permit.

FOREST GENETICS RESEARCH AT THE UNIVERSITY OF WISCONSIN*

Robert G. Hitt[1/]

For a number of years research has been conducted at the University of Wisconsin on various forestry problems. This work is carried on in

---

1/ Forester-In-Charge, Tree Breeding Research, Department of Genetics, University of Wisconsin.

the Soils Department by Dr. S. A. Wilde, in the Pathology Department by Dr. A. J. Riker, and in the Entomology Department by Dr. R. D. Shenefelt. All of these men are assisted by other well-qualified professional men and graduate students.

Realization of the need for a program of forest genetics research in Wisconsin resulted in the initiation of such a program in 1948. The research is carried on in the Genetics Department of the University of Wisconsin in cooperation with the Wisconsin Conservation Department. The general objective of the program is the improvement of the planting stock used for reforestation. The work has been organized under the following specific objectives:

1. Improvement of the genetic quality of the planting stock now going into reforestation through the utilization of seed harvested from the best existing native stands.

2. Selection of superior trees by progeny tests.

3. Hybridization for the production of improved strains.

4. Specialized studies.

I would like to discuss the first of the objectives later.

SELECTION OF SUPERIOR TREES BY PROGENY TESTS

To date, over 250 individual tree selections have been made in Wisconsin. Included are selections of red pine (Pinus resinosa), jack pine (P. banksiana, white pine (P. strobus), white spruce (Picea glauca), black spruce (P. mariana), and a number of trembling aspen (Populus tremuloides) and large-toothed aspen (P. grandidentata). By the standards which we are using at the present time, many of our original selections cannot be classified as phenotypically plus trees. However, they will be carried along in the testing work.

Open-pollinated seed was collected from many of the trees in the fall of 1948. This spring (1953), nearly 30,000 transplants raised from this seed will be set out in progeny test areas as well as in several breeding collection areas that have been established.

Basic to any breeding program is the building up of a collection of breeding material. The seed and scion collection to date for the Wisconsin Forest Genetics project includes 28 species of Pinus, 5 species of Larix, 6 species of Picea, and 3 species of Abies. These represent 304 different sources in 14 states, 7 Canadian provinces, and 13 foreign countries, and do not include any of the Wisconsin individual tree collections mentioned earlier. In order to avoid loss of all or a part of the collection by fire, disease, insects, etc., as well as having the material more readily at hand and perhaps have it

flowering about the same time as our native material does, several breeding collection areas have been established throughout the state. One area is to be established on a 20-acre tract which has already been allocated for this purpose in the University of Wisconsin Arboretum in Madison, a second area is at the Griffith State Nursery at Wisconsin Rapids, the third area is near the Trout Lake Forestry Headquarters in Vilas County, and a fourth area will be established somewhere in the northwestern part of the state near the Gordon Nursery.

HYBRIDIZATION FOR PRODUCTION OF IMPROVED STRAINS

Hybridization studies are being conducted relative to the establishment of desirable clones or strains of natural and hybrid coniferous forest tree species. Initially, particular emphasis is being directed toward the improvement of our native red pine. Dr. Heimburger, of the Department of Lands and Forests of Canada, as well as others have expressed the opinion that two or more strains of red pine may exist. Following the ice invasions centuries ago, the red pine moved north again. In so doing, part of the species moved up the eastern side of the Great Lakes and part up the western side. Through the centuries of "isolation" by the water barrier, distinctly different races may have developed. These races or strains, when cross pollinated under controlled conditions, may give rise to progeny showing hybrid vigor. Therefore, crosses are being made between different geographic types of this species.

Controlled pollination work is also being performed using the selected red pine trees growing in Wisconsin. Compatibility tests with this species are in progress. The possibility of producing hybrids between red pine and some of the other hard pines is being explored.

The hybrid resulting from crossing jack pine and lodgepole pine (P. contorta var. latifolia) which has been produced by the Institute of Forest Genetics and others shows promise. Efforts are being made to produce this hybrid here by utilizing selected native jack pine and crossing it with lodgepole pine pollen supplied by the Institute of Forest Genetics.

No major work is planned immediately with white pine since the Forest Pathology Research group has already undertaken breeding work with this species relative to white pine blister rust resistance. Cooperative efforts are anticipated on certain phases of the work at a later date, however. Breeding work with various species of spruce (Picea) is planned.

The tree improvement work with hardwoods has thus far been primarily concerned with Populus. Selection of desirable parent trees has been started. The production of hybrid seedlings has been undertaken and attempts are being made to produce polyploid material with our two more important species, trembling and large-toothed aspen. Since disease resistance is such an important factor in the poplar breeding work, cooperative efforts must be maintained with the Forest Pathology Research

group relative to testing any hybrid or polyploid material.

SPECIALIZED STUDIES

Vegetative propagation of selected plant material is an important process which the forest tree breeder must master and use. Trials have been initiated with red pine in an effort to find a technique for inducing root formation on cuttings. Various techniques, media, hormones, etc., have been employed in these experiments. Some greenhouse grafting has been performed, however results to date have been poor. Mr. C. E. Olson has just finished our greenhouse pine grafting and will begin grafting spruce. We plan to do some field or free-land grafting of pine and possibly spruce later this spring.

Methods to induce precocious or early flowering have been sought by tree breeders for some time. We have established 14 test areas in central and northern Wisconsin in order to test a number of different methods for their effectiveness in stimulating flowering on red pine. The treatments include spiral girdling, semi-circular girdling, wire strangulation, and checks or controls. In all cases a definite treatment effect has been noticed, with the spiral girdling being the most pronounced. Death of the terminals and in one case even death of the entire tree resulted from this treatment. As a result, new areas were established in which root pruning was substituted for the spiral girdling treatment. The first of these trials will be read this year.

In order to help our Conservation Department plan its annual cone-buying program, a cone crop prediction survey is made, generally annually. In addition, some cone-picking time studies have been undertaken.

Attention is being given to other specialized problems. These include the establishment and management of seed-tree orchards, improved equipment and methods for controlled pollination work, production of polyploid material, etc. In all phases of our work we are cognizant of the need for close cooperation between the various research groups relative to the production and testing of improved forest trees.

IMPROVEMENT OF THE GENETIC QUALITY OF FOREST PLANTING STOCK

I have reserved this topic for discussion last because we feel that it is one of the most important phases of our work demanding immediate attention. We feel that the most effective step which can be taken now to improve immediately the genetic quality of planting stock is the establishment of a seed procurement plan which involves certification. Measures should be taken to bring under management for seed production existing selected stands of forest trees of the species most important to the reforestation work in the Lake States region. The inferior individuals should be rogued out of these stands and management practices

established which would favor maximum seed production. The seed harvested would undoubtedly be of better genetic quality than that which is secured by present methods. Further, the seed harvested from these seed tree reservations would be certified.

Seed-tree orchards or farms should be established to supply future needs for forest tree seed of improved genetic quality. Progeny tests will serve to determine the best parental combinations to be used or left in these seed-tree orchards. Seed collected from the seed-tree reservations mentioned earlier would serve to meet present seed demands. Eventually, however, more and more seed could be produced in the seed-tree orchards. This seed would be of tested improved genetic quality.

We feel that this phase of the forest tree improvement program is so important that a proposal has been drawn up for the establishment of a program of certification of forest tree seed used in Wisconsin. This proposal was presented to our Conservation Department last August for their consideration.

In conclusion, I would like to say that our program, like the general field of forest genetics, is in the diaper stage. There are many changes to come. We feel fortunate, however, in being able to grow up with the new science. Further, we are encouraged by an ever-increasing interest in the general field of forest genetics. This conference with its fine attendance attests this fact!

WORK OF THE UNIVERSITY OF MINNESOTA AT THE CLOQUET EXPERIMENTAL FOREST

T. Schantz-Hansen 1/

Ever since I worked on the yellow pine provenance experiment on Benton Flat at the Priest River Station I have been interested in that phase of forestry. When I came to Cloquet, little was being done in that field, possibly because such studies are costly and results are slow in coming. True, we were doing a little with various exotic species of *Populus*, but there the general idea was to find something of value for windbreak planting. As I traveled through the north country on a now probably forgotten survey of cut-over lands more than 25 years ago, I was impressed by the great variation in the form and development of jack pine. It seemed to me that there must have developed strains or races of this species down through the years. Today, I am not so sure that what I saw were strains or races.

1/ Professor, In Charge of Cloquet Experimental Forest, School of Forestry, University of Minnesota.

In 1939, I succeeded in getting hold of some Bankhead-Jones funds for a study in provenance of jack pine. With the help of various forestry agencies in the United States and Canada, we collected seed from 38 locations. We planned to test not only the influence of provenance, but also the effects of the character of the parent trees. Thus in some places the seed was collected from 10 individuals of good form and 10 individuals of poor form, in some cases from good stands and from poor stands, and in some cases from trees with non-serotinous cones in a region where serotinous cones were normal. Collections ranged from as far south as Eau Claire, Wisconsin, and Peterson, Minnesota, north to Athabaska and Lesser Slave River and from the coast of Maine in the east to Saskatchewan in the west. Seed was extracted by hand after opening the cones in an electric oven at 130° F. Germination tests were made and the size of seed determined. The stock was sown in the forest nursery and planted in plots of 25 trees in a cleared area. The exact location for each selection was determined randomly. A spacing of five feet was used. As far as possible, all plots were made in triplicate.

Survival counts were made annually, and for a number of years height growth, form, and the presence of insects were recorded. It soon became apparent that insects were having a tremendous influence on the form of the trees. The shoot borer (Eucosma sonomana) and the pitch nodule maker (Petrova albicapitana) were the worst offenders since they often destroyed the leader and eventually the tree became an "apple tree" jack pine, regardless of the source. As I watched these trees develop, I could not help but wonder if many of our poorly formed jack pine were not the result of these outside influences rather than site. Possibly all our good virgin stands were the result of coincidence, originating while there was a minimum of insect epidemics, a minimum of fire, a minimum of rabbits, and a minimum of diseases.

There is not much to choose from between sources so far as survival is concerned. The lowest survival is 83 percent in the Wellston, Michigan source as compared to 100 percent in many sources. Annual height growth varied from 0.24 feet in the Eau Claire selection to 1.07 feet for the New Jersey selection. The New Jersey selection was a plantation from seed presumably from Minnesota. In general, the far northern selections have shown the slowest growth rate.

During the winter of 1947-48 we had severe winter injury. Many native species and natural stands in the woods showed severe "browning." Most severely affected were the selections from the Southern Peninsula of Michigan, in which 93 percent of the trees were injured.

Because of the insect damage, it has been impossible to arrive at any reliable conclusion as to the effect of the parent on the form of the tree. Possibly as the trees grow they will pass the zone of insect damage and develop into more typical trees.

The significant and valuable information to be had from this study is yet to come.

POPLAR, ELM, AND COLORADO SPRUCE INVESTIGATIONS AT THE UNIVERSITY OF MINNESOTA

D. P. Duncan[1]

The work in forest genetics at the University of Minnesota School of Forestry, aside from that which Dr. Schantz-Hansen has already discussed, consists of three projects, all of which are tree selection projects. None involves any active tree breeding. One of these is a *Populus* selection study, a second is concerned with elm selections, and the third involves a seed source study of Colorado blue spruce (*Picea pungens*).

POPLAR WORK

The poplar selection work was begun at the School in 1947 and additional collections were made during 1948. About 150 selections, including both hybrids from many sources and selected strains of several species, are included. The major objectives of this work have been three: (1) to find selections which are hardy under Minnesota climatic conditions; (2) to determine which selections show most rapid growth; and (3) to ascertain which selections are resistant to disease (including canker, leaf spot, and rust) and to insect injury.

The original collections included materials provided by the University of Wisconsin, by the Northeastern and Lake States Forest Experiment Stations, by the Cabot Foundation, by the Indian Head Station in Saskatchewan, by the Soil Conservation Service, and by many others, in addition to selections of material from promising cottonwoods in Minnesota and Wisconsin made by the School. The cuttings were assembled at Rochester, Minnesota at the Mayo Forestry and Horticulture Institute, where they were planted initially in nursery rooting beds. These rooted cuttings were planted out in 1948 in 12 tree blocks at a spacing of 8x8 feet, and additional field plantings were made in 1949. The site conditions in the planting area are extremely favorable with bottomland loam soils lying just a few feet above the fluctuating water table. The area on which most of the plantings were made is subject to periodic spring flooding.

Each year since establishment, records have been taken on these plantings with the cooperation of the Departments of Plant Pathology and Entomology at the University. These records provide data on the height and diameter growth, the form, and resistance to disease and insect injury of the 150 selections.

At the time of the last inspection of the plantations, when the trees had gone through five growing seasons beyond rooted cuttings, a number of selections had attained average heights of 30 to 35 feet and average diameters at breast height of 5 to 6 inches. Many showed severe cankering. A most interesting relationship between insect attack, cankering

1/ Assistant Professor, School of Forestry, University of Minnesota.

and wetwood has become increasingly apparent and is now being studied. However, considerable additional work must be done before this problem can be completely clarified.

We recognize that it is still far too early to draw any significant conclusions relating to the success of these poplars. Nonetheless, there are among the number in the plantation several which appear to give promise for wider planting in Minnesota. Seven of these have been selected for larger block plantings at Rochester and for trial under the much more difficult site conditions encountered at the Rosemount Agricultural Experiment Station. These seven include:

Mayo *Populus*	No. 21	*Populus deltoides* (U. of Wis. No. 6)
M.P.	No. 51	*P. angulata* x *P. berolinensis* (Oxford Paper No. 32)
M.P.	No. 56	*P. charkowiensis* x *P. balsamifera* (Dow No. 88)
M.P.	No. 58	x *P. robusta*
M.P.	No. 93	*P. nigra* (Cabot Foundation No. 18)
M.P.	No.123	*P. deltoides* (collected at Waukesha, Wisconsin)
M.P.	No.165	Urban poplar (collected from 30-year-old plantation in S. Minnesota, parentage unknown)

These selections are also being planted on the campus in St. Paul where they can be more closely observed.

Populus robusta which gives every indication of being an extremely good prospect for Lake States planting has been pulped on an experimental basis by the Central Research Division of the Marathon Corporation of Rothschild, Wisconsin. Although the final evaluation is not yet completed, these results should soon become available.

In addition to this work with poplars, a small trial is under way to determine whether an extremely fine group of quaking aspens discovered at the Quetico-Superior Wilderness Research Center is the result of a favorable genetic make-up or of exceptionally good site conditions. Aspens 34 inches in diameter without defect discovered there, have been reproduced by root cuttings. In 1949, they were planted along with root cuttings of aspen from medium and poor sites at the Research Center, at the Cloquet Experimental Forest, and at the North Central Agricultural Experiment Station at Grand Rapids.

ELM WORK

The work with elms has been undertaken to find whether species or strains which are resistant to Dutch elm disease and to phloem necrosis have other desirable growth characteristics and are hardy in Minnesota. Hardy selections of *Ulmus pumila* showing the rapid growth so desirable in windbreak and shelterbelt plantings, which at the same time are resistant to wind and ice-storm breakage, are also being sought. Japanese elm (*Ulmus japonica*) is being propagated since older trees in the state show many

highly desirable characteristics, particularly for ornamental and shade tree use. The Dutch-elm-disease resistant strain of *Ulmus campestris* (the Christine Buisman elm) has been found not to be hardy in Minnesota. *Ulmus parvifolia*, the true Chinese elm, is being tested but appears of questionable hardiness. In order to facilitate vegetative regeneration of elms, as well as other trees which appear to be desirable, a humidity chamber has been constructed in the School's St. Paul greenhouse where experimental regeneration studies will be undertaken during the next few years.

COLORADO BLUE SPRUCE

In addition to its ornamental value, Colorado blue spruce has been found to show the highest survival among all conifers on the heavy soils of western Minnesota. Here it is in high demand for windbreak plantings as well as for ornamental use. However, at least over much of Minnesota, this species shows susceptibility to *Cytospora* canker which destroys both its ornamental and its protection values. Since *Cytospora* is usually considered to be a species attacking only weakened trees, a selection which is fully hardy in Minnesota could be expected to show resistance.

In U.S.D.A. Miscellaneous Publication 287, Munns shows the range of Colorado spruce as extending from the Canadian border nearly to Mexico although it is most abundant in Colorado and Utah. An effort has been made by the School to obtain seed from as wide a geographical and elevational range as possible. To date, 14 sources have been secured from locations scattered throughout the Colorado, Utah, and Wyoming ranges of the species. Although Munns shows three small areas in Montana in which the species occurs, seed from these areas has not yet been obtained and appears to be very difficult to secure.

During the spring of 1952, eight sources were planted at the Cloquet Forest nursery and the remainder will be planted there this spring. When transplants become available, they will be planted in various areas throughout the state to ascertain whether any superior strains have been located.

FOREST GENETICS WORK AT MICHIGAN STATE COLLEGE

P. W. Robbins[1/]

The first work at Michigan State College endeavored to secure and produce trees suitable to the wide diversity of planting sites within the state. Professor Beal, and later Professor Bogue, hoped to find species that would produce good wood quality, and at the same time, make growth as rapid or faster than the native species.

1/ Associate Professor, Department of Forestry, Conservation Division, Michigan State College.

Professor Bogue started a forest nursery in 1904, from which western pines and firs, as well as eastern white, jack, and red pines, and white spruce, were sold for forest planting. Professor Bogue also started an arboretum for his first trials at East Lansing, with the hope that "progeny tests" would follow this early beginning. His selections included the following:

Pinus ponderosa var. *scopulorum*
Pinus ponderosa
Pinus jeffreyi
Pinus monticola
Pinus flexilis
Pinus rigida
Pinus strobus
Pinus banksiana
Picea abies
Picea engelmanni
Pseudotsuga taxifolia
Castanea dentata
Larix decidua
And others

The majority of these trees lived to produce fruit, and many of them are still alive.

Early in its 50 years of service to the Michigan public, the Forestry Department cooperated with the United States Department of Agriculture, Bureau of Plant Industry, in trials of exotic trees, both deciduous and coniferous. The most promising of these trials were Chinese chestnut, *Castanea mollissima*. Trees of this species reached fruiting age before they were removed to make room for the new building construction following World War II.

Professor Chittenden established a trial plantation of *Populus canadensis* (which is considered a hybrid between *P. nigra* and *P. tacamahaca*) and *Populus deltoides*, about 1917. These poplars made rapid growth and were later underplanted with white pine, and still later (1946) were harvested for their lumber when the expanding campus overflowed onto their site.

In 1926, Professor Chittenden secured some hybrid poplar cuttings and planted them at the Dunbar Forest Experiment Station at Sault Ste. Marie. These poplars made very rapid growth for three seasons before they succumbed to canker damage and winter injury.

In 1928, Professor Neilson of our Horticulture Department started his nut culture work at East Lansing and continued it later at the W. K. Kellogg Farm near Augusta, Michigan. Professor Neilson did some hybridization work, although the majority of his work was in selection of exotic and native scion wood from promising individuals which he grafted on native rootstocks. A large acreage at the Kellogg Farm was devoted to a "nut orchard." This "nut orchard" has been producing annual crops of nuts for some time. Unfortunately, no one individual has devoted much time to continuing this work since Professor Neilson's death.

The next work at Michigan State was trials of exotic conifers at the W. K. Kellogg Forest near Augusta, where ponderosa, lodgepole, Austrian, and Japanese red pine were established in forest plantations each of one acre or more.

In 1934-35, the Forestry Department secured from E. J. Schreiner, Oxford Paper Company, Oxford, Maine, the following hybrid poplars for trials at East Lansing: Andover, Rumford, Maine, Oxford, Rochester, and Geneva varieties. These hybrid poplars were planted in rows at East Lansing and cultivated. They made very rapid growth, many of them reaching 30 feet and 4 to 5 inches d.b.h. in five years. However, canker infections ruined the plantation about the time they reached interesting size.

In 1941, Scott S. Pauley, then a graduate assistant, experimented with many crosses of deciduous trees at Michigan State College. The war interrupted the fine work he started at Michigan State.

In May 1941, I established a planting of the following hybrid poplars that the Forestry Department secured from the Dow Chemical Company, of Midland, Michigan:

No. 52:	Populus charkowiensis	x	P. nigra plantierensis
No. 57:	Populus fastigeata	x	P. sobieriens
No. 69:	Populus angulata	x	P. berolinensis
No. 75:	Populus maximowiczii	x	P. trichocarpa
No. 76:	Populus nigra	x	P. laurifolia
No. 78:	Populus nigra	x	P. laurifolia
No. 94:	Populus charkowiensis	x	P. trichocarpa
No. 97:	Populus petrowskyana	x	P. caudina
No. 99:	Populus rasumowskyana	x	P. incrassata

These poplar hybrids were irrigated and cultivated, and they made a remarkable growth of 6 to 8 feet the first season. These plants were cut back the following spring, and the cuttings produced were used in trials on other college properties.

In 1942, a new plantation of these varieties was established in the nursery on cultivated ground. They were cultivated but received no irrigation, and again made an annual growth of 4 to 6 feet in height. The third year they were 1 to 2 inches in diameter, but leaf rust and cankers were developing on all 9 varieties. During the next two years, practically all the varieties were badly injured by cankers. The plantation was destroyed in 1946 to make room for new classroom buildings.

In April 1942, the Forestry Department initiated a series of hybrid poplar plantings in cooperation with the Dow Chemical Company, testing three new varieties, as well as five of the varieties planted in 1941 and 1942. The test plantings were distributed across the state from north to south at:

The Dunbar Forest Experiment Station, Sault Ste. Marie, Michigan
The Mancelona Plantation, Mancelona, Michigan
The Lake City Experiment Station, Lake City, Michigan
The Kellogg Forest, Augusta, Michigan

The results of these trials as reported by Dr. L. W. Gysel in the Michigan Agricultural Experiment Station Quarterly Bulletin, Vol. 32 (1): 156-165, August 1949, are:

1. For each hybrid, the total survival was marked by large differences between test areas and plots. A comparison by test areas showed the survival to be best in the Mancelona plantation where the average for two blocks was 96 percent. Hybrid 31 had the best average survival for all plots.

2. On the average, approximately 60 percent of the stems surviving were original; the remaining were sprouts. All of the surviving stems in the plowed and fitted plots of the Kellogg area were original.

3. The average height and average diameter of the hybrids in plots other than those of the Kellogg area were low. In the plowed and fitted plots of the latter area, the average height of all hybrids was 19 feet and the average d.b.h., 2.5 inches.

4. Some of the factors affecting growth and survival were borer damage, canker damage, climate, and soils.

5. Under the conditions of this experiment, the hybrids tested apparently will be of possible commercial value only in the southern Michigan test area, the Kellogg Forest, on ground which was plowed and fitted before planting and cultivated after planting. Here, on the basis of superior height and diameter growth, hybrids 30 and 48 were the best; however, both were highly infected with the fungi causing canker damage which may decrease future survival and growth.

FOREST GENETICS AT THE UNIVERSITY OF MICHIGAN

Stephen H. Spurr 1/

INTRODUCTION

The School of Natural Resources at the University of Michigan has maintained a small program in forest genetics since 1930 when research was initiated to develop chestnuts resistant to the chestnut blight. In keeping with the tradition of a liberal arts university center, each staff member has been permitted to develop his interest in forest genetics

---

1/ Professor of Silviculture, School of Natural Resources, University of Michigan.

independently, without the setting up of long-term group projects. Because the School of Natural Resources has close contact with strong departments of Botany and Zoology in the same building, and because no agricultural experiment station exists at the University, the research program in forest genetics has tended to remain on a small scale and to stress the interest of individual staff members and graduate students.

At the present time, work is in progress or has been initiated on four general problems: (1) the development of blight-resistant chestnut trees; (2) the testing of ponderosa pine for resistance to a rust tentatively identified as Cronartium cerebrum; (3) the development of a Norway spruce strain resistant to the spruce gall aphid; and (4) the testing of various European races of Scotch pine.

WORK IN PROGRESS

Blight-resistant Chestnut

The chestnut blight spread rapidly into the southeastern part of Michigan from 1927 to 1929. Chestnut planted in 1906 at the Saginaw Forest near Ann Arbor became infected with the blight after 1931. Beginning about 1930, a long-term program was initiated to develop blight-resistant chestnut stocks.

Chestnut is native to southern Michigan as far north as St. Clair County and provided an important nut crop in the state as long ago as 1888. In 1931, Michigan orchards were yielding 5-8 bushels of chestnuts per acre practically every year, bringing a price of from $60 - $100 per acre to the grower.

In 1930, over 2,000 seedlings grown by the Division of Forest Pathology from seeds collected from blight-resistant trees in Korea and Japan were tested in Ann Arbor by Professor Dow V. Baxter. These trees were grown in pots so that they could be transplanted into the field in the pots without exposing the roots. By virtually eliminating the possibility of death due to faulty transplanting, it was possible to test the seedlings solely for hardiness in southern Michigan. Most of this material was not frost-hardy, but 37 nut-bearing trees were selected for further study. In 1949, nuts selected from 15 of the best trees were planted out, and have been carefully followed since. In 1951, a second selection was made, this being nuts from the best single tree. Forty seedlings from this generation are now in a cold frame, and will be planted out in the near future.

In 1950, another lot of 100 seedlings of Castanea mollissina and crosses between C. mollissina and C. dentata were obtained. Some 60 of these plants have been planted in pots for three years. These pots have been placed in pits with top light designed to force juvenile height growth. The trees will be planted out in the University of Michigan Botanical Gardens this spring, and will eventually be matched with the selections obtained from the original 2,000 for hardiness, nut production, and nut quality.

The chestnut breeding program is well along and appears very promising. It may well lead to a revival of the nut-growing industry in southern Michigan.

Rust-resistant Ponderosa Pine

This is a story of two ponderosa pine plantations, one heavily infested with the rust fungus, and the other a healthy stand. These plantations and others representing five additional seed sources are now under study by Professor Dow V. Baxter and the Laboratory of Pathology in Forest Practice.

Resistance to fungi varies among races as well as species of trees. In 1928, ponderosa pine grown from Black Hills seed was planted in the Stinchfield Woods near Ann Arbor. Since that time, a rust fungus tentatively identified as Cronartium cerebrum has — together with "winter kill" — destroyed a large part of the stand. The majority of infections have occurred in the part of the plantation nearest an oak forest — an alternate host for the rust should the fungus prove to be Cronartium cerebrum.

In the second plantation, which is also near the oak, and which has been in the field for a longer period and therefore more subject to chance infestation than the first, no rust occurs. Differences in the amount of "winter kill," furthermore, are also apparent between the two plantations.

Pine stock from four different sources has been obtained and has been potted for later field inoculation tests to determine the susceptibility of different kinds of stock to this rust. A fifth source (Nebraska Sand Hills) will be represented by stock that is to be shipped this spring. Natural infection tests, as well as laboratory and greenhouse inoculations, are planned.

It is hoped that from this study the susceptibility of ponderosa pine to this rust may be determined. A corollary objective, of course, is to isolate strains of ponderosa pine that may be safely planted in the neighborhood of oak stands.

Norway Spruce Resistant to the Spruce Gall Aphid

In the Saginaw Forest of the University of Michigan, a 50-year-old plantation of Norway spruce is infected with the eastern gall aphid (Chermes abietis). Some of the trees have been heavily attacked while neighboring and even interlocking trees are untouched. A study has been initiated to determine whether this resistance is genetic, and to isolate if possible a strain of Norway spruce resistant to the gall aphid.

This study, being carried on by a graduate student under Professor Samuel A. Graham, involves the establishment of a plantation from open-pollinated seed secured from the infected plantation; the rooting of cuttings from

both susceptible and resistant trees; and controlled pollination of both resistant and nonresistant trees. The initial study is scheduled for completion about 1955, and will probably be followed up by other studies along the same line.

Scotch Pine Seed Source

In the Stinchfield Woods of the University of Michigan near Ann Arbor, three sources of Scotch pine were planted on similar adjacent sites in 1930 and 1933. These three plantations, covering 10 acres in all, have been followed carefully since that time. Permanent sample plots have been established, and each plantation has been given careful thinning treatment as required. The largest plantation represents seed from east Baltic Scotch pine trees (the so-called Riga strain) which are world-famous for their high quality. The two smaller plantations represent southwestern Europe (Bavarian) and northwestern Europe (Norwegian) stock.

In February 1953, a graduate student at the University (William H. D. McGregor) completed a master's thesis on the three plantations. His thesis includes a detailed study of the growth and development of these three plantations. In addition, it presents the results of careful measurement of 30 sample trees in each stand. These trees were studied to determine the nature and amount of injury and crookedness from all sources. In general, the Bavarian trees were found to be the fastest-growing and the Riga trees the slowest-growing. On the other hand, the Riga strain was the straightest and showed the least amount of injury. McGregor concluded that, in general, the Norwegian trees seemed to be doing the best, as an acceptable number of trees were relatively free from deformation and as their growth rate was considerably higher than that of the Riga strain. This conclusion is subject to further studies as the plantations develop.

PLANS FOR THE FUTURE

The School of Natural Resources of the University of Michigan is not concerned with large-scale tree breeding programs such as can logically best be carried on by forest experiment stations and land-grant colleges. Rather, our basic interest is in the solution of fundamental problems in forest genetics, and in the training of graduate-level students in this field, taking full advantage of the close relationships that exist between the School of Natural Resources and the various biological departments in the University of Michigan.

In addition to the projects described above, a number of similar problems await the attack of a properly qualified graduate student. For example, material is on hand for the study of resistance of white pine to the white pine weevil. Since the population of weevils in a white pine plantation is directly proportional to the circumference of the leader, a strain of white pine having thin leaders theoretically should be less conducive to weevil injury than the usual type of tree. One of the

at Stinchfield Woods seems to have unusually thin leaders. Seeds collected from this plantation will be planted with other seed sources in areas where weevils abound to determine (1) whether the narrow shoot is genetically controlled, and (2) whether this strain is actually more resistant to the weevil than other material.

Although no large-scale mass selection or tree breeding trials are contemplated, it is hoped to establish a small field planting of carefully selected stock of known genetic origin. An area of about 10 acres may well be set aside for this purpose. It is hoped to plant here material of known seed source, and of known genetic constitution. Promising hybrids may well be included. Although the planting will be small, the site will be carefully prepared, the trees will be cultivated as needed, and careful observations will be made. This material will be available to interested staff and graduates for further research. We believe that carefully tended field trials of this nature, although small, will provide far more information of a fundamental nature than can be obtained from casually established large-scale field plantings which receive a minimum of care.

Through studies of this type, it is hoped that the School of Natural Resources of the University of Michigan will turn out an increasing number of graduate students thoroughly and competently trained in the field of forest genetics.

TREE BREEDING WORK OF THE NEKOOSA-EDWARDS PAPER COMPANY*

Robert C. Dosen[1]

The Nekoosa-Edwards Paper Company has been growing, planting, and cutting trees for many years. Anyone engaged in forestry on almost any scale is cognizant of and interested vitally in forest genetics. We at Nekoosa-Edwards have attempted to follow genetics principles as closely as possible in our work.

An industrial approach to genetics can perhaps be summed up by the statement, "How can we by following proper silvicultural practices bring the greatest volume of wood from our forests to our mill in the shortest possible time?"

It has always been difficult to get the proper information on seed sources. Local seed has been used whenever possible, but there has been no guarantee that this seed has come from superior stock. When a nursery is planting over 2 million seeds per year it is not always possible to obtain the seed locally, and we have been forced to purchase from the open market. One

1/ Forester, Woodlands Department, Nekoosa-Edwards Paper Company.

big step for all nursery practices would be proper selection of seed from definitely known sources that had been collected from superior or elite trees.

We at Nekoosa-Edwards have seen many of the articles from the Institute of Forest Genetics at Placerville, California, and became interested in their work on the lodgepole-jack pine cross. The cones had come from jack pine pollen and a parent lodgepole pine and showed startling vigor. We then thought, can we establish by selection or hybridization, or both, forests of exceptional vigor that will produce quality wood in a shorter time. There are definitely known differences within a given species, and there are differences between different species whose utilization is the same. Example:

	Lodgepole Pine	Jack Pine
Solid wood per cord (cu. ft.)	95 - 98	83 - 86
Bark volume per cord (cu. ft.)	12.0	14.5
Density (lbs. per cu. ft.)	25.0	24.2
Yield - pulped (percent)	44.9	43.6
Strength tests (lbs. per sq. in.)	660 - 750	600 - 640

We next looked for the correct approach to use. Was it selection or perhaps hybridization? Nepco chose first to use hybridization, testing the feasibility of using lodgepole pollen on a parent jack pine. If this cross were successful, how would the progeny test in the field? How was the hybrid vigor; will it last or carry on when compared with native stock? If the aforementioned were all favorable, the question then arose: how will we produce seed on a large scale?

We first began pollination crosses in 1948. We have had a great deal of cooperation from Dr. Righter at Placerville, California. He sent the pollen to us, and also seeds that he wanted to have tested here. In 1951, following the pollination and maturation of the seed we planted our first hybrid jack pine-lodgepole pine in the field. This was followed by a planting in 1952, and in 1953 we will have one more planting. Definite differences are noticed in the hybrid trees that are planted. At the present time, it might be stated that we are checking these progeny of jack pine and lodgepole pine and probably will carry this on for approximately another 10 years. If results are favorable, the big question then is, how can we produce these at the rate of 1 million per year?

SOURCE-OF-SEED STUDY
BY NEKOOSA-EDWARDS PAPER COMPANY*

B. L. Berklund[1/]

Because of much evidence to support the importance of seed source and because Nepco has a large planting program, the company initiated study in 1950 to test geographic sources of red and jack pines and black and white spruces.

Seed collections follow the regions set up in the red pine study by the Lake States Forest Experiment Station, with sub-collections in each region. Collections are limited to Minnesota, Wisconsin, and Upper Michigan.

Twenty five sources of both red pine and jack pine were collected during 1950 and 1951, and were planted in November 1951. These will be 2-0 in the spring of 1954, at which time the jack pine is scheduled for planting in blocks of 14x14 rows at a 5x5 spacing.

Plans call for planting the red pine as 2-2 stock in blocks of 14x14 rows at a 6x6 spacing. Each species will be replicated three times in Central Wisconsin and three times in Oneida County.

Red Pine Seed Sources (1950-51)

North Central Minnesota
1. Max
2. Itasca State Park
3. Backus

Central Minnesota - Western Wisconsin
1. Pine River, Minn.
2. Spooner, Wis.
3. St. Croix Park, Minn.

Northeastern Minnesota
1. Nett Lake Area
2. About 25 miles NW of Ely
3. Near second lake, Echo Trail, Ely

Head of Lakes (Minnesota -Wisconsin)
1. Drummond, Wis.
2. Cornucopia, Wis.
3. Washburn, Wis.
4. Brule River State Forest, Wis.

Jack Pine Seed Sources (1950-51)

North Central Minnesota
1. Max
2. Solway
3. Hackensack

Central Minnesota - Western Wisconsin
1. St. Croix Park, Minn.
2. Trego, Wis.
3. Menagha, Minn.
4. Brainerd, Minn.
5. Brainerd, Minn. (2nd collection)

Northeastern Minnesota
1. Hunting Shack River, Ely
2. Nett Lake

Head of Lakes Area
1. Iron River, Wis.
2. Washburn, Wis.
3. Brule State Forest, Wis.

1/ Forester, Woodlands Department, Nekoosa-Edwards Paper Company.

Red Pine Seed Sources (1950-51)

Upper Peninsula of Michigan
1. Rock River - Munising area
2. Newberry
3. Palmer

Northeastern Wisconsin and lower Upper Michigan
1. Pine Lake (near Minocqua, Wis.)
2. Marinette, Wis.
3. Keshina, Wis.
4. Powers, Mich.
5. Hayward, Wis.
6. Maywood, Mich.

Central Wisconsin
1. Pray
2. Nepco Lake, Port Edwards
3. Nepco Nursery area, Port Edwards

Jack Pine Seed Sources (1950-51)

Upper Peninsula of Michigan
1. Trout Lake (near Newberry)
2. Shingleton

Northeastern Wisconsin and lower Upper Michigan
1. Near Minocqua, Wis.
2. Conover, Wis.
3. St. Germain area, Highway 70, Wis.
4. Marinette County, Wis.
5. Keshina, Wis.
6. Gladstone, Mich.

Central Wisconsin
1. Millston
2. Pray
3. Port Edwards
4. Adams

AN "EXTRA HEREDITY" APPROACH TO ASPEN BREEDING IN THE LAKE STATES*

Philip N. Joranson 1/

Early in 1952 a project was initiated for breeding native aspens for growing in northern and central Wisconsin. The Rhinelander Paper Company and the Marathon Corporation jointly are supporting the project, and Beloit College has made available greenhouse, laboratory, and office facilities. The goal of research is to determine whether adding one, or two, complete sets of the nuclear factors which determine a tree's inherited life potential, to the double set of such factors in the cells of the ordinary wild tree may constitute a profitable means (1) of increasing the per acre production of paper-making fiber, and (2) of improving upon the quality and utility of the fiber by producting a longer one.

Since several terms which are not familiar to all who are interested in the genetic improvement of forest trees are almost indispensable to a description of this project, it may be useful to define them here. Polyploid trees differ from the ordinary diploid trees, upon which we now

1/ Assistant Professor of Botany, Beloit College, Wisconsin.

depend, with respect to the number of sets of those microscopic, linear transmission structures — the chromosomes — which are present in the nuclei of all of their cells. On these chromosomes, collectively, reside all of the inheritance factors — or genes — which are transmitted to offspring in Mendelian fashion.

According to present information, the vegetative cells of ordinary wild aspens, as well as those of nearly all aspen hybrids, are each internally regulated by exactly 38 chromosomes in two similar sets of 19 each. This double set condition is referred to as diploid. A polyploid tree, on the other hand, is any tree which contains more than two of these complete sets of chromosomes in its vegetative nuclei. If there should be three such sets, the condition is described as triploid, and the four-set condition is known as tetraploid.

Since these distinctions cannot be understood very clearly apart from some acquaintance with the actual reproductive processes and with the physical basis of inheritance, there may be some value in coining a term out of common language and calling all polyploids "extra heredity" trees, thereby distinguishing the triploids and tetraploids collectively from most hybrids and the great mass of wild trees of non-hybrid origin. For want of a more precise non-technical term, the "extra heredity" tag will be employed in this report, where appropriate.

The most general effect of increasing the number of sets of chromosomes beyond the diploid condition has been enlargement in cell size. Sometimes individual plants are also larger. In tree species the length of tracheid fiber, which is related to the strength of paper manufactured from it, may be increased, but there may also be a similar effect upon fiber diameter and wall thickness. All of these factors, plus others, affect the quality of paper made from the wood pulp, and only by producing a sufficient variety of extra heredity woods for testing is it possible to determine either the net effect of all factors or the particular effect of any one factor upon the characteristics of the paper.

The design of the present project envisions the possibility of securing native triploid trees of both quaking aspen and largetooth aspen by detection of naturally produced triploids in the forest, by making crosses involving one polyploid parent where a suitable one can be found, and by artificial production of tetraploid trees, using colchicine treatments. In Sweden, all of these types of approach have yielded extra heredity breeding materials, some of which are promising and others too weak to survive, of the widely distributed *Populus tremula*, an European cousin of our own quaking aspen.

A search for triploid aspens in several localities in the Lake States was initiated last summer, and will continue this season. If triploid aspens occur naturally in North America, Swedish experience with *P. tremula* and other evidence would incline us to look for individuals and clones characterized by exceptionally rapid growth, unusually large leaves and buds, and large stomata.

Triploid seedlings and perhaps also a few tetraploid seedlings worth trying in Wisconsin might also be secured by applying pollen from triploid individuals of the European *P. tremula* to female catkins of our native diploid trees of both *P. tremuloides* and *P. grandidentata*. Through the courtesy of Dr. C. Heimburger, of the Ontario Department of Lands and Waters, such pollen was made available several weeks ago from Swedish triploid branches which he has propagated by grafting.

A third method for securing extra heredity stock of aspen is by use of colchicine or some other agent capable of interfering in cell division in such a way that many dividing cells in the growing regions of root tip and stem tip are converted from cells having a double set of chromosomes to cells having a quadruple set. This method is by no means always successful, nor does it guarantee a completely tetraploid plant. Efforts of this kind in Sweden, however, give some encouragement, and the method is a valuable one because it offers the possibility of combining in an extra heredity tree the divergent genetic contributions of two parents, both of which can be selected with a great degree of latitude and with possible recourse to parent trees which were involved earlier in crosses which have produced at least apparently desirable progeny. Doubling the number of chromosomes in a hybrid may also enhance the chances of securing a tetraploid which is fertile.

Several thousand hybrid seeds for colchicine treatment and controls were produced during the last seven weeks from about 20 different matings. These crosses are made in the greenhouse by the common method of placing flower-bud-bearing branches from trees of both sexes in water, transferring pollen to female catkins after about a week's development, and then caring for the branches another two or three weeks until the seeds ripen in the catkins.

Flower-bud-bearing branches were obtained from a number of trees in Wisconsin, Minnesota, and the Upper Peninsula of Michigan, including several collections sent through the cooperation of the Headwaters

Branch of the Lake States Forest Experiment Station and the Quetico-Superior Wilderness Research Center. Pollen samples were received from, exchanged with, or sent to Dr. Scott Pauley of the Cabot Foundation at Harvard University, and poplar breeders in Canada, Sweden, the Netherlands and Italy. In similar activities and in some cases also in other respects, there has been some cooperation with the genetics and pathology tree breeding projects at the University of Wisconsin, and with the Cloquet Experimental Forest of the University of Minnesota, the Diamond Match Company at Cloquet, the Minnesota and Wisconsin Departments of Conservation, U. S. Forest Service rangers, the Lake States Forest Experiment Station and its branch at Rhinelander, Wisconsin, Trees for Tomorrow, Inc., foresters with the two sponsoring companies, and others. A guide has been prepared to assist foresters in the field who are in a position to help locate superior trees bearing flower buds.

As early as possible, chromosome counts will be made from all types of material, and these will need to be continued over a considerable period, probably, in the case of seedlings treated with colchicine.

Colchicine-treated and control untreated seedlings from the same seed sources will be set out this spring in fenced test plantations at the Ripco Experimental Farm, the U. S. Forest Service Argonne Experimental Forest, on land provided by the Beloit Iron Works near Beloit, and possibly also near Rothschild, Wisconsin. Detailed records of many characteristics will be kept for all materials tested.

As early as the end of the second year of growth, wood samples from the larger seedlings may be ready for testing. The procedure will be, first, to make hand sheets, subject them to the usual physical tests for paper, and determine the pulp yield per unit weight of wood, amount of bleaching required, etc. Later, it is planned to make measurements of average fiber length, width and wall thickness, and to relate these results to those secured in the manufacture of hand sheets. Procedure in making these tests has been discussed with wood technologists at the Forest Products Laboratory in Madison and at the Institute of Paper Chemistry.

THE PRESENT STATUS OF FOREST TREE BREEDING IN CANADA

C. Heimburger[1]

Two main phases of forest tree breeding are commonly recognized, namely the conservational phase and the individual selection phase. The conservational phase aims at conserving and perpetuating the best germ plasm of existing tree populations, usually by means of various cutting methods

---

1/ Southern Experiment Station, Ontario Department of Lands and Forests.

directed towards the most successful natural regeneration of such populations. Methods of bulk selection are used and superior existing stands are sometimes selected and managed for seed production. The seed thus obtained is used in both natural and artificial regeneration.

The individual selection phase is supposed to serve the needs of artificial regeneration in providing seeds of superior genetic quality collected from selected individual trees, either directly or from so-called seed orchards where such trees are propagated vegetatively and managed in such a manner that the resulting seed material is more abundant and genetically superior to that obtainable from natural stands.

In Canada, we are at present chiefly concerned with the individual selection phase of forest tree breeding. Our chief aim is to serve the needs of artificial regeneration and to supply seed or plant material that from a genetic standpoint is best suited for such needs. Our tree breeding activities are closely linked with tree planting activities and are centered in areas where such activities have created a demand for planting stock of superior genetic quality. From 1939 to 1952, all forest tree breeding work in Canada was carried out in cooperation with the Subcommittee on Forest Tree Breeding of the Associate Committee on Forestry of the National Research Council of Canada. In 1952, the Associate Committee on Forestry was disbanded and the Director of Forestry, Department of Resources and Development, assumed the responsibility for the activities of the Subcommittee.

WORK IN BRITISH COLUMBIA

In a short description of tree breeding activities in Canada, I will start at the west coast and begin with the work of W. A. Porter in British Columbia. Mr. Porter is employed by the Canada Department of Agriculture and is selecting western white pine for resistance to blister rust. A sizable tree planting program is under way on the coast of British Columbia, and several forest nurseries are operated in this connection by the Provincial Government. The main species planted on cutover areas that lack satisfactory natural regeneration are Douglas fir and Sitka spruce. Western white pine is admittedly a very valuable species. It could be raised in the same nurseries and planted along with the other two species with very good economic results, if we had plant material that we knew would survive under natural conditions. With such plant material we could hope to increase the proportion of white pine in the coast forest and thus as a whole tend to produce more diversified and valuable kinds of trees.

Mr. Porter is at present engaged in the selection of seemingly resistant individual western white pines in the more accessible coast forests. The material is grafted on stock imported from the Savenac nursery in Montana, and the grafts will be tested in a disease garden with Ribes and in a climate that is very favorable to the natural infection of white pine by blister rust. Later, material from the interior of British Columbia will be included in the tests, and there will also be a chance to test

some of our eastern selections for resistance. If and when good resistant material has been selected and tested, it will most probably be used, in one way or another, for seed production. The seed produced in this manner will be in good demand by the existing forest nurseries, and elsewhere.

WORK IN SASKATCHEWAN

Dr. W. H. Cram is working at the Forest Nursery Station, Indian Head, Saskatchewan. The Forest Nursery Station is operated by the Canada Department of Agriculture and is distributing planting stock for prairie shelterbelts. There is a need for better climatic and soil adaptation as well as more vigorous growth in the species used for this purpose. The main species concerned is Caragana arborescens, a shrub native to Siberia and now widely used for shelterbelts in the prairies. Self-sterile individuals of vigorous growth are being selected, tested for combining ability and seed producing capacity, and propagated vegetatively for the establishment of seed production units. Rather wide variation in several important characters has been found within the material of this species introduced thus far into the Canadian prairies, and additional material is being assembled from the United States and elsewhere. Several inbred progenies have been produced and are being tested.

Work with white, Black Hills, Norway, and Colorado spruces presently consists largely of the seedbed performance of one-parent progenies of selected trees. Variation in the stratification requirement of the seeds, and in the proportion of good nursery transplants produced has been found. The material is being subjected to further tests for vigor and adaptability. White spruce enters the southern prairies both from the west and from the east, besides being native to the northern prairies. Several taxonomically distinct forms occur in different regions and offer a wide scope for hybridization and selection of superior types. Colorado spruce is also being used in prairie shelterbelts and lends itself well to further improvement in adaptation to such a new habitat.

Work with Scotch pine is proceeding along similar lines. Material of different geographic origin and of seed-bearing age is at hand. Nursery performance tests with one-parent progenies of this material are under way. Later, such progenies will be tested for their performance in shelterbelts. Similar work with Manitoba maple (boxelder) is also in progress, on a rather small scale thus far.

Various poplars of the cottonwood and balsam poplar groups are being widely planted in prairie shelterbelts, and a fairly large collection of different clones and seedling populations of this kind has been assembled at Indian Head. The native cottonwoods root very poorly from stem cuttings and many of the so-called Russian poplars are subject to canker. The northwest poplar, a natural hybrid from North Dakota, has been widely planted in recent years, but roots rather poorly from stem cuttings and is a slow grower. Hybrids of various native poplars and

Russian poplars have been obtained and are being tested for rooting capacity from stem cuttings and general performance in shelterbelts.

WORK AT PETAWAWA

The work of M. Holst at the Petawawa Forest Experiment Station, Chalk River, Ontario, is being described in a separate paper and, therefore, it is only mentioned here that he works with spruce, hard pines, and larch.

WORK AT THE CENTRAL EXPERIMENTAL FARM

Dr. A. W. S. Hunter, of the Division of Horticulture, Central Experimental Farm, Ottawa, has in recent years started some work in breeding for resistance to Dutch elm disease. Crosses between the diploid *Ulmus pumila* and the tetraploid *Ulmus americana* are being tried. *Ulmus pumila* is being treated with colchicine to induce chromosome doubling, and apparently resistant Dutch elm varieties have been imported. At the Dominion Experimental Station, L'Assomption, Quebec, white elm seedlings are being artificially inoculated with Dutch elm disease and methods of vegetative propagation of elm worked out. Dr. Hunter has also produced some black currant x red currant hybrids for my work with blister rust resistance in white pine.

WORK AT THE SOUTHERN EXPERIMENT STATION

My own work is being carried out at the Southern Experiment Station, Maple, Ontario, under the direction of the Division of Research, Ontario Department of Lands and Forests, and is, in part, supported by grants from the Ontario Research Council. It is concerned with white pine, aspen poplars, and, more recently, with 2-needled pines. The work is closely connected with our Division of Reforestation which operates several nurseries that supply planting stock to farmers and to county and municipal forests. It also collects seed and operates a seed extraction plant. There are fairly large areas of abandoned farm land on light soil in southern and central Ontario that are gradually being replanted with stock produced by these nurseries. Planting is also being done on some cut-over and burned areas with insufficient natural regeneration.

White Pine Studies

White pine was one of the main species raised and planted at the beginning of reforestation activities in the early part of this century, but blister rust and weevil soon restricted the use of this very valuable species. Work in selection for resistance to blister rust follows the lines already established by Dr. A. J. Riker in Wisconsin. Grafts are being produced in the greenhouse and outside with scions collected from

trees that are free from the disease under conditions of severe natural infection. These grafts are being set out in special beds that can be covered with lath screens and burlap, and subjected to artificial inoculation. Black currants are being grown in a lath house to supply the necessary inoculum.

The plantation of white pine at Pointe Platon, Quebec, is our main source of resistant materials. In addition, we have obtained scions and seeds from apparently resistant trees in Denmark and Germany, as well as some of Dr. Riker's selected clones. Cooperation with the Northwestern Blister Rust Control Project of the U. S. Department of Agriculture in Spokane was initiated in 1951, and we are at present growing and testing some of their supposedly resistant western white pine selections and are sending them some of our selections. An exchange of pollen with various organizations in the United States and Europe is also under way. The work is being coordinated and kept up to date by the Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U.S.D.A., Washington, D.C., which receives and distributes reports from workers with blister rust in white pines in the United States and Canada.

The white pine weevil is being taken care of by selecting outstanding trees, free from weevil attack but growing under conditions of severe weevil infestation, in plantations and natural stands. Grafts from such trees are first subjected to the standard tests for resistance to blister rust and studied with respect to leader thickness. The so-called slender leader trees of the entomologists have been found to be less susceptible to weevil attacks than trees with thick leaders. Leader thickness is admittedly a character that is strongly influenced by the environment, and the grafts at first show a rather strong influence of the size of the original scions on their shoot thickness. Later, inherent differences in shoot thickness become apparent and the different clones become more uniform in this respect. The material is grafted on rather uniform stock and is growing under uniform conditions in the nursery.

The native white pine is further being analyzed in respect to its segregation into ecotypes and climatic races by means of strain tests. In the fall of 1946, a fairly large seed collection was undertaken in different parts of Ontario and seeds from selected trees, selected stands, and bulk collections from several localities were assembled and later sown in three of the Provincial forest nurseries. The resulting material, about 200 thousand plants, was set out in 25 test plantations located in southern and central Ontario, and one in Quebec.

One strain of western white pine and seeds from the plantation at Pointe Platon, Quebec, are included in this. The plants are set out in replicated lots at a spacing of 2½x5 feet, to provide material for very early thinning and individual selection. These strain tests have already yielded preliminary information in respect to inherent superiority in growth form and growth rate, about the most promising localities for seed collection, for reforestation purposes.

In addition to working with pure eastern and western white pines, other species and hybrids of 5-needled pines are being assembled, tested for resistance to blister rust and weeviling, and evaluated in respect to other characters. Material of this kind has been obtained from several arboreta, parks and botanical gardens in the United States and in Europe. Some such hybrids have been produced at Maple. Of these, Pinus peuce and its hybrids with eastern white pine are particularly promising because of their high degree of resistance to blister rust and their early flowering. The resistance to blister rust seems to have a different genetic basis from that of eastern white pine. The early flowering might be a valuable character in the production of stock for grafting, to induce early flowering in other breeding materials of white pine. It is possible that other valuable characters can be obtained from Pinus Griffithii, the Himalayan white pine, and Pinus parviflora, the Japanese white pine. Both are crossable with the North American white pines and we have hybrids at hand. An evaluation in this respect of the Appalachian white pine has just been started.

Aspen Studies

In contrast to the work with white pine, the work with aspen poplars is at present not directly connected with the reforestation activities of our Department. It is an outgrowth of former work with the breeding of poplars for shelterbelts in the prairies. We happened to produce something that was valuable and are receiving further requests for poplars suitable for the production of match stock and pulpwood. As aspens usually yield better match stock than cottonwoods and balsam poplars and their hybrids, and also can grow on medium fertile soils that usually are more available to forest industries in Ontario, the breeding work at the present time is concerned only with aspens and their hybrids.

Of the native aspens, P. tremuloides is the most widely distributed in Ontario. We have very good material of this species in northern and especially in northwestern Ontario. This material has yielded very promising hybrids with northern forms of European aspen in Sweden. Promising results have also been obtained by crossing good trembling aspen from northern Minnesota with P. adenopoda, a Chinese aspen found planted in Rochester, New York. Northern trembling aspen does not grow well when planted in southern Ontario, probably because its day length requirements are not satisfied. Trembling aspen, native to southern Ontario, has been crossed with Polish aspen in Denmark, and some of the resulting very heterogeneous hybrid seedlings seem to be of promise to us. In recent years, we have been sending pollen of trembling aspen in increasing quantities to Europe, especially to the Scandinavian countries, for the production of hybrid aspens to be grown there for match stock. A dwarf form of trembling aspen that flowers very early in life has been found in southern Ontario, and this form is now being put into use as dwarfing stock to induce early flowering in other aspen materials. Some western forms of tembling aspen have also been obtained and tested, but these are susceptible to a Melampsora rust under our conditions.

The other native species, P. grandidentata, does not seem to be as dependent on day length as P. tremuloides and we have successfully moved material from the northernmost parts of its range, as well as from the southernmost parts in the United States, to southern Ontario. This species grows well on light sandy soils, and for this reason appears to be promising for planting work.

It hybridizes easily with P. alba, the silver poplar, and natural hybrids are found abundantly wherever the latter species is planted. Only a very small proportion of such hybrids seem capable of growing into large trees, however. The greater part soon become stagheaded and decadent under natural conditions, although they all grow very well in a cultivated nursery. The cross P. alba x grandidentata has been made artificially several times, using different P. alba materials for this purpose, and has yielded seedlings quite similar to those found in nature. Some of the oldest and largest natural hybrids of this kind have been taken into cultivation and appear to be most promising under our conditions. The crosses P. canescens x grandidentata and P. tomentosa x grandidentata have also been made and have yielded more aspen-like hybrids than P. alba x grandidentata. They grow very well with us but are as yet too young for any determination of their forest quality.

European aspen, P. tremula, has been introduced from several parts of Europe and a population from Czechoslovakia, of excellent growth form, has shown such good growth that we are starting to propagate it for tests on a larger scale. This species is sometimes badly chewed by grasshoppers when young plants are set out in grassy areas, in contrast to the native aspen species. Thus far, it has not been attacked by Hypoxylon canker, to which P. alba and some forms of P. canescens seem highly susceptible. We have also obtained some of the Swedish triploid aspens, and these grow quite well and flower abundantly with us, although thus far the growth is not superior to that of our best native aspen materials.

We thus have abundant aspen materials at hand for a very promising breeding program, and also clones of pure species and hybrids that could immediately be put to work in producing good match stock and pulpwood, were it not for a major bottleneck. This bottleneck is the problem of propagation. Aspens are notoriously difficult to grow from seeds and many difficulties are encountered in raising hybrid seedlings. This can only be done by using very intensive horticultural techniques and is thus far not economically feasible on an industrial scale. It is possible, however, that soil conditioning agents and fungicides in time will help us in solving this problem. Aspens cannot be propagated by stem cuttings by direct planting in a nursery. It has been possible to root stem cuttings of aspens with the aid of plant growth hormones in specially prepared propagation beds, but as yet not on an industrial scale. Propagation by means of root cuttings is quite feasible and has been put into practice with several forms of P. canescens in Europe, but we have not found this practical under our conditions. Grafting of aspens on rooted cuttings of P. alba is also quite feasible but probably too expensive for industrial application. Budding has not been successful to any

degree in our hot summers. It is possible that bench-grafting of aspen cuttings on to cuttings of P. alba with good rooting capacity in time might be perfected to such a degree that it will lend itself to industrial application. This is the most promising approach to date, and we are working on it.

I believe the ultimate solution of the propagation problem lies in the breeding of aspen hybrids with satisfactory rooting capacity from stem cuttings and otherwise acceptable as planting materials for match stock and pulpwood production. We have found P. alba with good rooting capacity planted in Ontario, of which breeding materials are available. We have also obtained a population of P. alba of Hungarian origin, of excellent growth form, and are each year obtaining additional P. alba materials from Europe and elsewhere, for further tests. We have found that rooting capacity of P. alba is partially dominant in crosses with aspens. The crosses P. alba x grandidentata and P. alba x tremula are particularly promising in this respect, and in exhibiting hybrid vigor. It still remains to combine the useful characters of P. alba and available aspen materials in such a manner that they will produce aspen-like hybrids with good rooting capacity from stem cuttings. This will necessarily require the raising of more than one generation of hybrids and, even with the best techniques available, take some time.

Hard Pine Studies

The work with red pine and other 2-needled pines is again closely tied in with reforestation. At the beginning of my work at Maple, Ontario, some 6 - 7 years ago, the problem was purely quantitative: we needed more red pine seed for our nurseries and experiments were started to increase seed production of young red pine plantations. Intensive thinning and partial girdling have given very promising results in this respect.

In recent years, the European pine shoot moth has been damaging young red pine and Scotch pine in southern Ontario so much that it has become a serious problem. The breeding of a red pine having resistance to the shoot moth is highly desirable. It probably will be very difficult, if not impossible, to accomplish this through selection alone. Thus far, it has not been possible to cross red pine with another pine species of the Lariciones group, to which it belongs, although all the possibilities have by far not been tried out in this respect. It may also be possible to work with Austrian pine which has some resistance to the shoot moth, and with this species as a basis to produce hybrid 2-needled pines suitable for replacing red pine and Scotch pine in areas where the shoot moth is now a problem. This looks like a long-term project, but it is well worth while, because southern Ontario is by no means the only area where the pine shoot moth has become a serious problem. This latter phase is now being carried out in cooperation with Mr. Holst.

Future Trends

As abandoned farm lands will be planted up, reforestation activities in southern Ontario are bound to decrease. As the population increases, more intensive silvicultural and management methods will be economically possible on a wide area further to the north, and other research stations might then conceivably be established there. Then the present work will supply a background of technical experience in the individual selection phase of forest tree breeding. At that time we also should be thinking more about the conservational phase than at present. This will apply particularly to the management of the more tolerant tree species by means of various kinds of selective cutting, with artificial regeneration supplementing existing natural regeneration.

TREE BREEDING PROGRAM AT THE PETAWAWA FOREST EXPERIMENT STATION

Mark Holst[1/]

The objective of the work in forest genetics and tree breeding is to produce strains of trees which, in a defined environment, possess the ability for maximum utilization of the productive capacity of the forest soils and thus increase the return in wood and money from the forest.

The degree of success in obtaining this objective is based entirely on the tree breeder's knowledge of the genetic composition and the local and regional variations of the species concerned. If such knowledge is not available or is incomplete, the tree breeder must work for solution of the problems involved and join and promote cooperative investigations closely related to his main line of investigation.

It is obvious that the yield from the forest could be increased considerably by proper fire protection, intensive silvicultural methods, close utilization, and intelligent management. While these means are mostly concerned with protection and improvement of a system already in existence, tree breeding is concerned with selection of the best types found and with creation of something new and better.

Having defined the objective for tree breeding and its place in the general forest research program, we may turn to the Petawawa breeding program and give the reasons for the line of investigation we have chosen. The wood-using industries are of considerable importance in the Canadian economic system. Of these, the pulp industries and the sawmills are the most important and almost exclusively based on a supply of coniferous wood. With the facilities available for tree breeding, it has been of importance to limit our efforts and concentrate on the most important species. The spruces and the hard pines are therefore our main fields of investigation.

1/ Forestry Branch, Canada Department of Resources and Development.

In the following are listed some of our main problems.

GENETIC COMPOSITION, NATURAL AND CLINAL VARIATION

It is of tremendous importance for the tree breeder to have a clear picture of the variation found within the species with which he is working.

While the genetic composition and the natural variation can be studied in the field, the clinal variation must be investigated in various experiments. Botanical notes, herbarium material, range maps, and handbooks of dendrology may furnish a preliminary framework for the investigations. The study of local yield tables compared with meteorological data serves also as a valuable guide, especially where a species has a north-south distribution.

Very little work has been done along these lines in North America, but from the available material we may obtain the following information:

The White Spruce Problem

The white spruce now found in the eastern and middle part of the North American continent is descended from a spruce that, during an interglacial period, came south and east from the gene centrum around the Bering Sea. White spruce seems closely related to the spruces of Japan and eastern China. It is difficult exactly to picture what distribution white spruce had during the Wisconsin glaciation. It has certainly been in the east and may have gone south along the emerged continental shelf. But how far west was it found? Bog pollen analyses indicate that it, together with black spruce, may have been found in the upper Mississippi region. The climate along the east coast was very wet and foggy during the glaciation, while the climate in the middle of the continent was quite dry. This fact has some influence on the white spruce types of today. The eastern types seem more sensitive to a change in moisture than to a change in temperature, while the opposite seems to be the case with the western types. The provenance experiments at Petawawa indicate that there are two different thermoclines, one pointing east and one pointing west. This is peculiar, but may in part be explained by the influence of day length. When the day length cline is investigated we find a good correlation for all types from the continental part of the Province of Quebec and westward, while the coastal types from extreme eastern Quebec and New Brunswick behave quite differently. We have, then, an indication of a tree race formation which does not follow the general clinal variation.

This is an important fact to keep in mind and it strongly supports the importance of keeping the selection program inside one well defined climatic region.

Experiments designed for the study of clinal variations serve the following theoretical and practical purposes:

1. To establish what clines are in existence.

2. To define more exactly what influence the clines have on wood production.

3. To work in the above information with the general forest classification for preparation of limits for seed distribution.

4. To set out races of both positive and negative value.

With a tendency to oversimplification we may say that selection work in a specified area may prove useless if a race from another area can outgrow the "native race" on home ground. Several such cases have been reported in the European provenance literature; the most impressive is the case of the German races of Norway spruce being superior to the native Norway spruces in southern Sweden and producing 20-50 percent more volume.

The Red Spruce, Black Spruce Problem

An interesting problem is found in the relation between red spruce and black spruce. Both species survived glaciation in eastern North America. Red spruce was apparently only found in the Appalachian Mountains, where it developed into a very tolerant, relatively slow growing "stayer type" able to compete with the hardwoods. Black spruce survived in a much longer east-west fringe south of the glacier and developed into an intolerant pioneer species capable of invading raw soils, etc.

This indicates that we have, right under our noses, two species which behave physiologically like the European and the Japanese larch, and therefore might prove as valuable in producing an heterotic hybrid.

Red spruce types from the southern Appalachians have been collected for further investigation of this possibility, and hybrids made about 10 years ago give promise that a fast growing hybrid can be produced.

The Norway Spruce Problem

Norway spruce has been widely planted both in Canada and the United States. In a study conducted over many years it has been possible to find types well adapted to the climate. An investigation, furthermore, revealed that breeding for weevil resistance might be possible and the best types have been combined by controlled pollination to obtain material for further investigation of this possibility.

The Problem of Hard Pines

Red pine is peculiar in being an inland shore pine and growing mainly on sandy soils. All through the range there is but little variation in form and botanical features, and it seems very close to being a pure line. The reported provenance experiments indicated clinal variation, even though the material has not been analyzed from this point of view,

and a closer study might reveal the distribution of certain physiological races. Only in one case reported from New York is there a strain which is somewhat different from the rest, and which might show promise of being a plastic type, i.e., a type capable of adapting itself to many environments. Such types are very useful in forestry and important to the tree breeders.

Very little is known about jack pine but our general impression is that there is quite a variation both within the stands and between different climatic regions.

We have here listed some of the problems in the most important conifers. For further study, provenance experiments are under way in red, white, black, and Norway spruces, and in red pine and jack pine. These experiments are in various stages of progress but it is planned to have the test plantations established in various important climatic regions within the next five years. To that end, a seed bank has been established at Petawawa to take care of the seed until the collections are complete.

DETERMINATION OF SELECTION VALUE IN SMALL POPULATIONS

Progress in tree breeding is based on selection of good stand material and it is expected that the selection is only of value within one general climatic region, at least as far as growth is concerned.

To secure progress, a large number of trees must be tested and, as the rating of the selected trees must be based on the progenies, various methods can be applied.

1. Open pollinated seed is collected from each selected tree and kept separate in the trials. This method is relatively simple and a large number of trees can be tested.

2. Controlled pollination with either one father or a standard pollen mixture. This method is much more laborious and relatively few trees can be tested.

3. Self-pollination, a somewhat faster method than No. 2 especially if larger bags, in which male and female flowers can be isolated, are used.

Method No. 1 has its limitations especially because we do not know the male parent. The tree might have been pollinated by a pollen mixture, which might express the average genotype of the stand, or it might be pollinated by some trees one year and by other trees the next year. We believe though, that the dominant growth genes of the female tree should emerge in the progeny test. The ease with which a large number of trees can be tested makes this method very important.

Methods No. 2 and No. 3 are much slower to work with and only a limited amount of seed can be obtained and only relatively few trees can be tested. These methods are well suited for detailed study of the variations in small populations. The self-pollination technique, especially, looks promising and valuable to the tree breeder, as it might be possible to determine the breeding value of single trees by the behaviour of their self-pollinated progenies.

Single trees of the previously mentioned conifers have been selected for phenotypical appearance, and a large number of open-pollinated, one-parent progenies are now under trial.

A fairly large number of artificial hybrids and self-pollinations have been established both in white and Norway spruces and in red and jack pines for determining the breeding value of single trees.

INTERSPECIFIC AND INTRASPECIFIC HYBRIDS

Through cooperation it has been possible to cross the Petawawa types of red pine and jack pine with eastern and western races in the hope that we might be able to produce a plastic type or even be able to combine frost-hardiness with high yield. This work is still in progress, and other species will be taken up for these investigations. Several spruce hybrids have been attempted but results are still uncertain and not ready for publication.

VEGETATIVE AND GENERATIVE PROPAGATION

Multiplication of selected material is an important part of tree breeding work. We have evidence that the techniques used in the mild climate of western Europe are not too successful in the continental climate at Petawawa. Many improvements, aiming at an average survival of 80 percent or over, have been made on the grafting technique and on the handling of grafted plants. Both greenhouse grafting and outside grafting are done and materials suitable for vegetative propagation by cuttings have been produced on a scale large enough to establish seed orchards.

We have furthermore put a great deal of work into producing root stocks suitable for the inducement of early and abundant flowering. In hard pines and in spruces we have found suitable material and intend eventually to produce our own seed for root stocks.

Another important problem is that of inducing trees in the forest to flower abundantly. Various methods of girdling and fertilizing are used to increase seed production. Some of the methods investigated seem quite promising and might eventually be applied in practical silviculture.

Good facilities for propagation are found at Petawawa. A greenhouse with attached work room has been built. Our nursery has been enlarged considerably and an irrigation system installed. Labor supply is quite satisfactory, as we can draw laborers from the station crew in the busy spring period.

4. Boyce Thompson Institute for Plant Research, Inc., Yonkers, N.Y.
   Clyde Chandler

   Hybridization, selection and testing of larch, natives and exotics.

5. Maria Moors Cabot Foundation for Botanical Research, Harvard University, Petersham, Mass.
   Scott S. Pauley, Albert G. Johnson, Helge Irgens-Moller, Wm. J. Gabriel

   Studies of variation in *Populus*, *Pinus*, *Quercus*, *Acer*, *Betula* and *Picea*.

Although the above outline presents at first glance a rather impressive array of forest genetic research activity in progress in the Northeast, one should not be beguiled into concluding that silvicultural thought and practice is in any way more advanced in that area than in other parts of the country. Environmentalist doctrine is still firmly entrenched, and much silvicultural research and practice is still based on the assumption that intraspecific diversity does not exist in Northeastern tree species.

Planting is done on a comparatively modest scale in most Northeastern states, and this situation may account for the tendency to place greater emphasis on the modernization of economical, rather than biological, aspects of silvicultural management. Unfortunately much of the planting stock that is utilized is still grown from seed of unknown or uncertain origin. This is a peculiarly anomalous situation, in view of the fact that forest nursery practices in the Northeast are otherwise of high calibre.

THE COMMITTEE ON SOUTHERN FOREST TREE IMPROVEMENT*

Robert D. McCulley 1/

In January 1951, foresters in the South took the first step toward formation of a genetics research coordinating committee, when they met at Atlanta, Ga., "to assess the status of our knowledge of genetics as related to trees and to determine the status or extent of the application of this knowledge." There was also the hope that leads would develop, pointing the course which research in the forest genetics field should take, and the part each individual and organization should play. As a result of this meeting, a 12-man Committee on Southern Forest Tree Improvement was organized with its membership representing all phases of forestry in the South at the technical level. This committee met for the first time in June of 1951.

1/ Research Forester, Lake States Forest Experiment Station.

The central committee first organized permanent subcommittees on Geographic Source of Seed, Genetic Control of Seed (production of genetically superior seed), Tree Selection and Breeding, and Progeny Testing. The chairmen of these permanent subcommittees and a nucleus of membership were selected from the central committee. Additional members who were especially qualified to offer help in the particular field of subcommittee responsibility also were chosen from outside the central committee. These subject matter committees were to draw up possible research programs in their respective fields and report back to the central committee. Arrangements were also made for the preparation of guideline publications showing how to go about genetics work in a reasonably sound manner, and for publication of a semi-annual news letter.

During the past two years this committee has sponsored eight publications and reports on tree improvement work and has undertaken a regional cooperative study of geographic sources of southern pine seed. In addition, it must receive much of the credit for a general wave of interest in southern tree improvement research.

The committee has defined its objectives as:

1. To advise and assist those interested in the improvement of southern forest trees in arranging and conducting research and development programs.

2. To provide a clearing house for information on forest tree improvement.

3. To provide for or assist in coordination in the conduct of a South-wide program of tree improvement research and development.

4. To foster and encourage the advancement of knowledge of southern tree genetics.

OF THE INLAND NORTHWEST REGION*

Paul O. Rudolf[1/]

In July 1950, a meeting was called at Missoula, Montana, to form an informal and continuing forest genetics steering committee containing representatives from all interested agencies, to stimulate interest in forest genetics and to coordinate research in this field within the region. This meeting provided an opportunity to review the current

1/ Forester, Lake States Forest Experiment Station.

status of forest tree improvement work in the Inland Northwest region, and out of it developed a committee composed of representatives of the following organizations:

Bureau of Entomology and Plant Quarantine
Division of Blister Rust Control, Spokane, Washington
Forest Insect Laboratory, Couer d'Alene, Idaho

Bureau of Plant Industry, Soils, and Agricultural Engineering
Division of Forest Pathology, Missoula, Montana

Montana State University
School of Forestry, Missoula, Montana

University of Idaho
School of Forestry, Moscow, Idaho

U. S. Forest Service
Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana
Northern Region, Division of Timber Management, Missoula, Montana

Washington State College, Pullman, Washington
Department of Agronomy
Department of Horticulture
Division of Forestry and Range Management

This committee, in contrast to the Southern Tree Improvement Committee, contains no representative of industry.

The functions of the committee at the outset were listed as follows:

1. Compile literature on genetics.

2. Disseminate information, possibly through an unscheduled newsletter, to include reports of progress on local projects and work in other regions.

3. Prepare definitions of superior trees or stands as a guide for field men in selection.

4. Keep oriented on main problems, screening projects and setting priorities.

5. Direct projects to graduate students.

6. Hold meetings at appropriate times.

In 1952, the committee carried through Item 3 by issuing "A Guide for the Selection of Superior Trees in the Northern Rocky Mountains." This 10-page report was published by the Northern Rocky Mountain Station.

PROBLEMS NEEDING STUDY IN GROWING MORE PRODUCTIVE SAWTIMBER TREES

H. E. Ochsner[1]

We have heard of the work being done in the forest genetics field in this and other regions of this country as well as in other countries. Problems needing study in this region are, I am sure, of a similar nature to those being studied and proposed for study in these other places.

First I would like to say that in talking about sawtimber trees, veneer as well as sawlogs are included.

A word might be said about the relative importance on a more or less long-range basis of sawtimber production in the Lake States region. The 50 million acres of commercial forest land in the three states is some 10 percent of the 461 million acres of commercial forest land in the United States. Of this 50 million acres, all but the swamps and poorest sand has in the past produced, and will again be capable of producing, sawtimber, much of it of high quality. The inadequacy of the supply of good grade sawtimber is shown by the continued over-cutting of our sawtimber and the small proportion of requirements supplied by the Lake States forests.

With over three-fourths of our forest lands capable of producing high-value sawtimber, a long-range program such as is involved in genetics research should give adequate attention to improvement of sawtimber productivity.

The principal sawtimber species among the softwoods are red or Norway pine and eastern white pine. To grow better pine sawtimber faster, the problem is primarily related to reforestation. Although more than 1,800,000 acres have been planted up to the present, probably almost half of which is red and white pine, there remains a large area to be planted. The present rate of reforestation in the Lake States is about 70,000 acres annually and appears to be on the increase.

Since reforestation work involves a substantial cash outlay, the quality and productivity of the planted trees is of particular importance to those doing the planting. For sawlog production, the kind of trees we plant now will affect the crop up to a century or more hence. Until the final harvest at the end of the rotation, there will of course be an opportunity to select and weed out the poorer trees, trees with slower growth characteristics, poor bole form, crooked and rapid taper, heavy and persistant branching, twisted grain and other undesirable characteristics. We need to know what to look for in terms of external characteristics that may have significance as to heritability. Foresters who do the marking or selection of trees in intermediate or selection cuts or select seed trees to leave could then be guided by this information.

1/ Assistant Regional Forester, North Central Region, U. S. Forest Service.

With the cost of planting the trees, exclusive of nursery stock and the fixed costs of ownership and management, the same regardless of the class of stock used, a considerably increased cost for stock that will increase production and quality would be good business. Superior growth rate, quality of the sawlogs or other products produced, and resistance to disease and insects would justify higher stock costs. The only increased cost of producing such superior stock would be the increased cost of the seed. Better growth rates would reduce the cost of release and increase survival. Better form would reduce the need for close spacing and non-commercial thinning.

Hardwoods present a different problem because they are almost entirely reproduced naturally. Very few hardwoods are planted. Because of the specialized uses of hardwoods, the development of trees with the most desirable wood characteristics for these uses is of importance. High growth rate, both diameter and height, straight stems, small branches, self pruning, low stem taper, resistance to rot, and other desirable characteristics should be striven for. If we knew more about how to judge the desirable external characteristics and vigor of trees that are due to heredity rather than environment, the forester could do a better job toward improving future stands in making selection cuts.

This brief discussion could only hope to touch upon a few of the problems and needs in growing more productive sawtimber trees in the Lake States. A thorough problem analysis to provide a sound basis for a coordinated program on a long-range basis, it seems to me, is urgently needed.

PROBLEMS NEEDING STUDY IN GROWING MORE PRODUCTIVE TREES FOR PULPWOOD*

B. L. Berklund[1/]

TREE BREEDING AND IMPROVEMENT

Both paper makers and foresters have in mind a dream tree which has all possible desirable qualities including long fiber, dense wood, fast growth, etc. However, most field foresters do not have the facilities or time to get into tree breeding very seriously. I shall, therefore, limit my remarks to some practical genetic improvements that we can make in normal forestry operations.

1/ Forester, Woodlands Department, Nekoosa-Edwards Paper Company.

Today we are approaching the height of an intense planting period participated in by all types of ownerships. At this point people in the pulpwood field can help themselves by a more serious attitude to the matter of seed source. There is difficulty to control seed source and most often it must be obtained where available. However, we foresters have probably taken the course of least resistance in the matter when there is sufficient evidence to indicate need of definite policies on seed collecting.

The same can be applied to grading of nursery stock. We sometimes lose sight of our goal in our stress for millions of trees and number of acres planted.

Those companies who own their nurseries have a wonderful opportunity to practice quality control, particularly where nursery production and reforestation are under the same control. Most foresters and nurserymen in the forestry field are cognizant of today's basic genetics and tomorrow's future forests, and are taking steps to that end. For those who are not doing their best in this respect, plans should be made to incorporate the basic knowledge of genetics, striving for quality as well as volume production.

GENETICS AND CUTTING PRACTICES

Now, let us consider the matter of genetics and cutting practices. There are many healthy signs indicating the sincerity among forest owners to practice good forestry. However, in our zeal to try new methods and ideas we may lessen our caution and reach too energetically to promising short cuts.

Over the past 25 years, American investigators have done much good applicable forestry research and more is now in progress which will give valuable results. It has been said that if all our forest land received good forestry practice, production of forest products could be tripled or quadrupled. It should be safe to say then that if we applied all that we know about forestry today the quantity of wood produced could be doubled. It follows then that our big job today is to sell application of forestry research first to our foresters, then to our operators.

Economic reasons in one form or another are usually cited as to why certain forestry practices are not done. Economics should be the yardstick in any practical forestry enterprise. It isn't always easy, however, to project today's economics 20 to 50 years hence. What might seem good economics today may prove to be false economy.

If one considers what a plantation with ideal spacing can do as compared to wild land varying all the way from unstocked to over-stocked stands, I don't mean to be overly optimistic by saying the "sky is the limit." For sake of classification, let us call planting the ABC end of forestry and hybridization the XYZ end. In between we have what I would call the

"meat" of good forestry, and it is in the D-to-W spread where practicing foresters can be of influence by taking the reins.

Today, it sometimes costs up to $40.00 per acre to plant. On such difficult planting chances, theoretically, it means that one might spend an amount approaching $40.00 per acre to insure regeneration by proper harvesting methods. Without getting involved in the interest factor of financing, it means that stumpage might be considerably reduced on intermediate cuts preparatory to the final cut if that is what is required to get regeneration. It wouldn't be infeasible to consider giving away the stumpage in intermediate TSI cutting.

Today, several Wisconsin mills are buying wood in Montana, Colorado, Wyoming, and Canada at very high freight rates. Let us suppose that we can some day reduce average freight cost from $10.00 per cord to $5.00 per cord by getting more local wood. On a mature local stand with 20 cords per acre, we theoretically have $100.00 per acre to play with. It would appear a wise investment to spend considerably more of this saved freight than is now spent, in such a way as to assure regeneration. Here again it must be recognized that the interest factor would reduce the actual value of the freight saving. I, of course, am not advocating that we should spent the $40.00 or the $100.00 on every acre of land, but I am advocating a review of our thinking on harvesting policies. Money put into forestry work is an investment, but that spent on freight is not.

In the foregoing there are, to be sure, many economic aspects not touched upon, but the point I wish to leave is that if we don't incur some of these expenses now they will come up in the future and may turn out to be more costly.

Most foresters will agree that using a diameter limit of cutting tolerant species is better than nothing, but it is basically wrong for intolerant, even-aged species. Yet I could quote sale agreements or contracts from both public and private forestry agencies which specify diameter limit cutting for jack pine and aspen stands.

The long-range effect, particularly in jack pine areas where cones open, is bound to be a net genetic deterioration of future stands. How much this will be I cannot answer. Is one foot per generation plausible or even somewhat conservative? In areas of serotinous-coned mature jack pine, why is there a diameter limit at all?

Why do these practices persist? Is it the economics of (a) high marking costs, and (b) lack of profit in an operation by producers, or is it a casual indifference by foresters as long as they can continue to fill today's quota of wood? If it is economics, we should perhaps reconsider the figures on high regeneration costs and amounts spent for freight. If it is primarily indifference, then we should face the job of selling complete forestry to production foresters and their producers.

Certainly we might look more critically over the jurisdiction we have as foresters, with an ear bent to the long-term genetic considerations as well as to the short-term present-day economics.

FOREST GENETICS IN RELATION TO WOOD QUALITY

Benson H. Paul 1/

When growing trees for the production of lumber, the quality of the final product is a primary consideration. The breeding of trees for disease, insect, or drought resistance, or for rapid growth, will fall short of complete success if the final wood product is of inferior quality. Timber quality, according to Richens (6), 2/ includes both anatomical and chemical properties of the wood.

In the consideration of wood quality from the anatomical viewpoint, the interest lies in fiber length in proportions of springwood and summerwood, which in turn influence density; this may be high or low depending on the intended or prevailing use. High density is desired for great mechanical strength and high pulp yields on a cubic foot and on an acre basis. Shrinkage, warping, and other properties of wood affecting its satisfactory use are related to density and anatomical structure in one way or another. Appearance or figure displayed by growth rings in wood is another feature eagerly sought for special uses. In many cases, therefore, the objectives of tree breeding need to be two- or even threefold.

The main object of tree breeding, according to some popular ideas, is to produce trees of very rapid growth. This at first appears to be a most worthy objective. If trees can be developed that will reach merchantable sizes in a small fraction of the time now required, it will be a great advantage to the timber grower. However, if for one reason or another, the wood produced from this rapid growth proves unsuitable for its intended use, then the user will be at a great disadvantage.

1/ Chief, Division of Silvicultural Relations, Forest Products Laboratory (Maintained at Madison, Wisconsin, by the Forest Service, U.S. Department of Agriculture, in cooperation with the University of Wisconsin.)

2/ Underlined numbers in parentheses refer to the list of numbered references at the end of the article.

(This paper was illustrated by slides)

Among the faults recognized in rapid growth of coniferous species under natural conditions are low specific gravity and strength. Another fault that may accompany these is excessive shrinkage along the grain. For some uses weight of the wood, or high strength, are not important. This is true for many uses of white pine, but even in white pine it has been found that when growth rings are as few as 4 to 6 per inch the wood is unsuitable for match stock, one of the important uses of white pine. The reason is that in cutting match sticks from wide-ringed blocks, many of the match sticks contain only the weak springwood portion of the growth ring and, as a result, they lack the necessary strength for striking. Other white pine wood with 12 to 16 rings per inch produced satisfactory match sticks, since in this case some of the stronger summerwood was present in each match stick.

Initially wide-ringed wood in young southern yellow pines usually is below average density. It has short fibers, and the fibers themselves are made up of fibrils that lie at a large angle with reference to the axis of the fiber. This anatomical arrangement in the fiber walls gives rise to unusually high shrinkage of the wood along the grain during drying, which results in warping that makes it unsuitable for many uses. If rapid growth is to be an objective in such species, then an effort ought to be made to develop trees in which the fibrils have a small angle to the axis of the fiber. This may take a long time to accomplish, since evolution of wood characteristics may be expected to take place very slowly. According to Arthur Koehler (5), wood is the most conservative part of a tree from an evolutionary standpoint. This is evident in a number of genera, like the oak and pine, in which the wood of a number of species cannot be separated on the basis of its structure, although botanical characteristics of fruit and flowers upon which species classification is based may have significant difference.

In our native species, there are variable widths of growth rings under different conditions of environment. Also, these variations in growth rate may result from changes of a silvicultural nature that take place naturally or as a result of treatment of a stand. Rings may be wide at first and gradually become narrower as the trees become larger and relative growing space of trees becomes less. Along with this change in ring width, in the southern pines accompanying changes have been observed in the size of fibril angles. With initial slow growth of trees, the fibril arrangement becomes stabilized at small angles much nearer the pith, although perhaps no sooner in years than in wider-ringed trees. Investigations along this line are in progress.

In breeding trees having maximum diameter growth, the objectionable structural tendencies of the wood need to be overcome. Width of rings also affects appearance of finished lumber, particularly in species with prominent summerwood bands. When considerable areas of summerwood are present on the surface, as in flat-sawed lumber, the

paint-holding capacity is lower than when individual summerwood areas are relatively small, as in quarter-sawed surfaces. Variations in the springwood-summerwood ratios in growth rings likewise vary with environmental conditions. The total amount of summerwood has been seen to be influenced by soil moisture during the growing season. Extremely dry or wet growing seasons give highly contrasting amounts of summerwood. Total springwood seems to be influenced by crown size and, at a given cross section in the tree, by proximity of the green crown when other factors are equal.

In studies of rotary-cut veneer from second-growth Douglas-fir, it was found that wide rings resulted in an uneven distribution of springwood and summerwood that gave an unbalanced sheet (3). The veneer from wide growth rings did not have the fine texture desirable for faces. Production of Douglas-fir timber yielding high-grade veneer logs appears to be a silvicultural problem calling for growth-rate control and also for pruning to rid the trees of persistent dead branches. For this species, not less than 10 rings per inch is recommended for high-quality face veneer.

The direction of grain and presence of figure in wood have been considered from the standpoint of developing strains or hybrids that will have high value on account of their attractiveness. H. G. Champion (2) in 1927 grew a large percentage of spiral-grained offspring from seeds of spiral-grained trees. As a result, he claimed that spiraling was hereditary. However, because of the variable occurrence of spiral grain among our native species, there is some evidence that spiral grain develops also from other causes. Sometimes spiral grain will occur only late in the life of a tree. In many cases the degree of spiral changes, or it may spiral first in one direction and then in another. In some released ponderosa pine trees, it was observed that the degree of spiral was reduced by acceleration of growth; and in one of the trees, the spiral reversed its direction. General observations indicate that spiraling is associated with slow growth and becomes intensified with retardation of growth in diameter.

Interlocked grain appears more likely to be hereditary than spiral grain. It is usually characteristic of most trees of a species; for example, sweetgum.

In Finland, the Forest Research Institute (4) tested hereditary tendencies of figure in birch. Four-year-old trees grown from seeds of parent trees having figured wood were planted in 1929. After 6 years, 44.6 percent had developed figure and, after 9 years, 61.7 percent. It was claimed that figure could be detected in trees as young as 2 years in the nursery beds. It was stated, also, that figure formation slowed down the growth of the birch and that the figured trees developed a bushy habit of branching, requiring pruning for the best results. Stakes were used to hold young figured trees upright, since the winding wood fibers caused the stems to become crooked. In Finland, grafting is practiced to reproduce the best racial features of figured birch.

A few years ago curly aspen in Maryland attracted much interest. In a letter from Schreiner (8) (1946) the origin was traced to a hybrid, Populus canescens, resulting from a cross of European white poplar and European aspen. It was distributed in this country as a shade tree. The wood of this particular clone had interlocking fiber, and it is reported that individual trees were sold at high prices ($700 to $800) for furniture and cabinet use.

Black walnut is a species in which occasional trees have figure highly valued for veneer. The cause of figure in walnut, like bird's eye in maple, is not clearly understood. A number of years ago, a highly figured black walnut tree, known as Lamb's walnut (1), was propagated by grafting. A specimen thought to have originated from that tree, sent to the Forest Products Laboratory recently, showed no tendency toward a figured grain.

Pillow (7), a number of years ago, examined sugar maple for the presence of bird's eye. He discovered a tendency toward the formation of dimples -- supposedly the forerunner of bird's eye — in young suppressed advance reproduction. If bird's eye can be recognized in small trees, then they could be marked and favored in making thinnings and the proportion of bird's eye increased in a maple forest.

Wood from only two hybrids from the Institute of Forest Genetics has been tested at the Laboratory; a natural hybrid of Jeffrey and Coulter pines and a hybrid of knobcone and Monterey pine. Both trees were of relatively rapid growth. They were tested for specific gravity and shrinkage. These trees did not show any outstanding wood characteristics in their favor over those of the parent species other than rapid growth. The wood, however, was characterized by abnormally high longitudinal shrinkage, although not equaling high values obtained previously in the wide-ringed wood of several other coniferous species.

Objectives in tree breeding, therefore, should include the important factors that control the use requirements of the final product. Accentuation of a single phase of development may be insufficient. The apparent advantages in volume growth per tree may lead to a disadvantage in the usefulness of the lumber from it. A well-rounded background knowledge of environmental influences upon wood quality is basic to the formulation of objectives in tree breeding. A test of the quality of wood resulting from experiments in forest genetics needs to be made at the earliest possible opportunity in order to find out whether new types of wood structure exist and, if so, which ones are most suited for further development. The selection and propagation of trees that produce figured wood of above average value for a species appears to have rather definite possibilities.

References

1. Anonymous
1927. Walnut Men Seek Figured Grain Tree.
Chicago Journal of Commerce. Nov. 2.

2. Champion, H. G.
1927. An Interim Report on Progress of Investigations into Origin of Twisted Fibre in *Pinus longifolia*. Indian Forester. January.

3. Fleischer, H. O.
1949. The Suitability of Second-growth Douglas-fir Logs for Veneer. Journal of Forestry 47(7). July.

4. Heikinheimo, O.
1940. Om odling av masur-björk. (Cultivation of Figured Birch.) Skogen 27(9): 165-167. illus. (Trans. by Geo. S. Perry.)

5. Koehler, Arthur
1939. Heredity vs. Environment in Improving Forest Trees. Journal of Forestry 37(9). September.

6. Richens, R. N.
1945. Forest Tree Breeding and Genetics. Joint Publication No. 8. Imperial Bureau of Plant Breeding and Genetics, Cambridge, England.

7. Pillow, M. Y.
1930. "Bird's Eyes" in Maple Are Not Due to Dormant Buds. Hardwood Record, Chicago. September.

8. Schreiner, E. J.
1946. Curly Aspen. (Letter to Forest Products Laboratory, April 12.)

FOREST GENETICS PROBLEMS NEEDING STUDY IN MICHIGAN - MINOR PRODUCTS (MAPLE SYRUP)

P. W. Robbins [1]

The first work on improving maple at Michigan State College started when an anonymous donor, interested in bird's-eye maple, gave funds for research to determine the cause of bird's eye in sugar maple. Professor Heweitson of the Horticultural Department and I conducted this research. Scions and cutting wood from sugar maple trees with identified "bird's eye" were secured from trees on the campus at East Lansing and from the Lake States Forest Experiment Station branch at Dukes, in the Upper Peninsula of Michigan. The cuttings and grafts which were made the first year were a complete failure.

---

[1] Associate Professor, Department of Forestry, Conservation Division, Michigan State College.

In the second season of this project, sugar maple seedlings were potted and forced in the greenhouse, and an equal number were lined-out in nursery rows. Bud grafting, using buds from sugar maple carrying the "bird's eye" were made on the lined-out and greenhouse-grown root stocks. Many of the bud grafts were successful, but war activity, together with exhaustion of the funds, stopped further progress.

The production of maple syrup and sugar is an important crop from our farm woodlots in Michigan, Wisconsin, and Minnesota, as well as in the New England States. The gross value of the 1952 crop for Michigan was approximately one-half million dollars. Michigan, Ohio, and New York have demonstrated that a sugar bush owner may earn $0.60 to $3.50 per hour in his sugar bush, depending upon the sap season.

There has been no outstanding labor-saving device or mechanical equipment developed during the past period of rapid increase in labor costs which will balance the lag in the increased selling price of maple syrup. For example, it was long a common practice to pay a laborer for his day's work in the sugar bush with one gallon of syrup. Maple syrup is selling for $5.50 to $6.00 per gallon, and operators cannot hire labor for $6.00 per day to work in the sugar bush. Therefore, a logical way to meet these labor costs is to boil only sap of high sugar content.

The sugar content of sap from maple trees usually varies from 1.5 to 4.0 percent by weight, although it has run as high as 7 percent in a tree found in New Hampshire. Sugar maple wood, of course, is in continuous demand by the furniture industry. For these reasons there is great need for the selection and breeding of new strains of sugar maple trees which will produce high quality lumber rapidly and at the same time produce sap of a high sugar content. Such a hybrid or selection will do more to encourage the maintenance and improvement of the maple farm woodlot than nearly any other forestry program we can offer the farmer.

PROBLEMS NEEDING STUDY IN DEVELOPING DISEASE-RESISTANT TREES*

A. J. Riker 1/

By hardiness we mean the ability to withstand the difficult features of the environment. They are easy enough to name -- too much or too little of temperature, of moisture, of light, and of the various essential mineral salts; as well as too much toxic material either in the air or in the soil.

All of these factors influence the growth of trees and may cause physiological or nonparasitic diseases. Further, these factors also influence the pathogenic bacteria or fungi as well as the interaction between the trees and such microorganisms which we call disease.

1/ Professor, Department of Plant Pathology, University of Wisconsin.

Too little time is available for discussing more than a few representative examples of disease situations that may influence hardiness.

Earlier on this program, I spoke about tree breeding for disease resistance with white pine and with poplars. In this connection, let me emphasize that the breeding work is aimed at improved quality. Emphasis has rightly been placed on disease resistance where disease is the most important factor limiting growth. However, we know that disease resistance is only one item in quality. Rate of growth, tree form, quality of the wood, ability to withstand Wisconsin's winter (especially unseasonably early and late freezes) as well as other items involved in environment or site — such items are considered in selecting and developing elite trees.

Trees that are hardy in one location may not do well in another. This may be critical in the planting program and may explain failures in natural reproduction. Needle droop is an excellent example. Dr. R. F. Patton has demonstrated that needle droop is not a parasitic disease, as we had feared at one time. Needle droop develops when the evaporation of water from the needles exceeds the uptake from the roots. The growing tissue at the base of the needles is injured or killed and the needles droop down. This is particularly bad in certain sandy soils, where grass competition is severe and where a rapid decrease in the moisture content may occur easily.

Crowding of natural or planted seedlings may provide a number of difficulties. If the growth in the trees slows down, they may develop susceptibility to a variety of insects and fungi. At the time the crowns begin to close, there is particular danger from root and butt rot. Certain insect and disease problems have appeared seriously in plantations in some of the eastern states (e.g., the Rochester watersheds). Forest management practices, such as suitable thinnings and improvement cuttings, which keep the trees growing vigorously, may do much to overcome such hazards.

Related problems have appeared when large areas of even-aged stands of similar or identical species were growing. For example, near Goodman, Phelps, and Mountain in northeastern Wisconsin, the insects and fungi combined to produce the burn blight complex and to destroy or to discourage the jack and red pine trees over considerable acreage. Once the epidemic started, no barriers were present to slow it down or possibly to stop it.

Since we are planting so many trees every year, the question of weed competition is an extremely serious one that affects not only survival but also the rate of growth. Not far from here (northwest of Rhinelander at the entrance to the McNaughton Prison Camp) one can see large trees that were clean-cultivated for several years after planting. Nearby are similar trees that grew with weed and grass competition. They are less than half as tall with a volume of wood correspondingly much decreased.

Obviously, clean cultivation is expensive even under favorable circumstances and impossible in much rough or stony ground. However, the recent development of selective herbicides suggests the possibility of using them for increasing the growth of seedlings during the first few years.

Another interesting situation perhaps bearing on hardiness is the frequency with which certain species of trees form root grafts underground between individuals. This has been surprisingly common among northern pin oaks and certain other species, as shown by J. E. Kuntz, C. H. Beckman, and their associates. When a tree is cut, the root system left in the ground frequently is adopted by neighboring trees to which it is grafted. This helps account for some of the rapid growth shown by neighboring released trees. Not only do the remaining trees have more light from above as well as more moisture and nutrients from below, but also they have an expanded root system. Furthermore, the stumps remain alive for a time and sprouts are encouraged.

FOREST GENETICS PROBLEMS IN GROWING INSECT-RESISTANT TREES*

H. J. MacAloney[1]

Little information is available on the subject of insect resistance in forest trees. Much of the general background material on which this discussion is based was obtained from Painter's "Insect Resistance in Crop Plants," although he stated that little had been done on forest insects. This discussion, which is primarily devoted to susceptibility studies, is based partly on published material and partly on unpublished reports from other stations. The problem of insect resistance in forest trees is extremely complicated -- it would seem that more attention, for one reason or another, has been paid to studies of the resistance of insects to control rather than to studies of the resistance of the plant itself to insect attacks.

The entomological work connected with breeding trees for resistance to insects differs from research into a control problem. A population must be built up and maintained in the laboratory or the forest, rather than be destroyed. The difficulties in carrying on such a long-time or long-maturing project such as tree growing, are apparent. It is of considerable interest to know that some of the previous speakers have encountered difficulty in preventing insect damage in their tree breeding or disease resistance studies. The projects in the West on susceptibility of pines to bark beetle attack and susceptibility of pines to reproduction weevil attack, carried on in cooperation with the Institute of Forest Genetics, at Placerville, California, are the outstanding examples of tree breeding to prevent insect attack.

1/ In charge Forest Insect Laboratory, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Milwaukee, Wis.

Much of the research on resistance and susceptibility has been developed through management and cutting practices designed to prevent further damage or losses in stands already existent. The bark beetle susceptibility classification for "east-side" ponderosa pine stands in northern California and Oregon, and the risk-rating method for individual ponderosa pine trees have given excellent results in controlling damage by the western pine beetle. Following these methods, areas operated a decade or more ago still show a substantial differential between the number of trees attacked and the losses in untreated areas. Similar criteria have been developed and are being tested in western white pine stands in Idaho, where selective logging of low-vigor trees reduces the amount of timber killed by the mountain pine beetle.

In the North Central Region some information on limitation of attack or resistance to injury has been obtained during the course of research work on plantation insects. Studies of the red-headed pine sawfly, for example, have shown that serious infestations develop under certain stand conditions. Choice of planting sites, with due regard to the presence of the alternate hosts on which the nymphs develop, is a very important factor in prevention of severe damage by the Saratoga spittlebug. Injury by the white-pine weevil may be reduced through silvicultural practices by creating growth or stand conditions, in the early years of the plantation or natural stand, that will be unfavorable for development of the weevil. These practices, again, are designed to decrease susceptibility in stands already existent and infested. We are in a better position now to advise on selection of planting sites and tree species than we were 20 years ago when large-scale planting was started in the Lake States, but more research is needed before we can solve some of the factors that determine susceptibility or resistance.

In connection with the discussion on maple syrup production and the selection of maple trees with the highest sugar content in the sap, attention was called to the fact that sugar maple is a favored host of the forest tent caterpillar. This insect is in outbreak form in the Lake States at the present time and continued heavy feeding in maple sugar orchards could result in a reduction in sugar content, thereby necessitating more gallons of sap to produce the required syrup concentration.

FOREST GENETICS PROBLEMS IN GROWING HARDIER TREES: ANIMAL FACTORS

Frank D. Irving, Jr.

1/ District Game Manager, Wisconsin Conservation Department.

The animal factors to consider in planning tree improvement can be divided into two classes: (1) animal injury, and (2) wildlife benefits. Animal injury can be an important factor in growing trees, and successful efforts to reduce it would have definite value. Wildlife interests can expect to benefit directly from tree improvement by emphasizing desirable characteristics for wildlife, and indirectly by the improved conditions for game which will result from other improvement programs.

Animal injury to trees is a special animal-plant coaction that varies greatly in importance with time and location. The most significant damage occurs as the result of a browsing animal feeding on young trees. Deer, rabbits, and hares if present in high enough density can kill or injure many commercial tree species. Porcupines, squirrels, and other rodents also cause local problems.

Three possible ways are available in which animal injury can be reduced by tree improvement: (1) reduce palatability, (2) increase early growth rate, and (3) increase tolerance to browsing. (Palatability as used here refers to the qualities of a plant that affect its selection by grazing or browsing animals.) We know from experience that the palatability of individual trees varies, but we need to know more about how much of the variation is due to the genotype. Porcupine damage in northern hardwood stands often demonstrates this point. Some trees are damaged severely year after year while other nearby trees of the same species, size, age, and condition are untouched. The same apparent variation in palatability is more difficult to see in connection with deer and rabbit damage to young trees. However, a study of browse utilization would probably indicate that certain individual food plants are more highly preferred than others where food supplies are adequate to offer a free choice.

Faster early growth can reduce animal injury by getting the tree above the rabbit and deer browsing zone in less time. The more winters the young tree is exposed to browsing, the more likely it is to be injured. If black ash sprouts can grow out of reach of deer in two growing seasons they are only exposed to serious damage during one winter. It is unfortunately true that fast early growth is usually associated with high palatability. Thus selecting stock for increased growth rate would tend to increase danger of animal injury in one way while decreasing it in another.

An increase in the tolerance to browsing would tend to reduce animal injury by reducing its importance. Few foresters would begrudge the deer and hares their rations, if the young trees recovered from browsing and showed no permanent effects. Here again we are faced with the question, "How much does this tolerance to browsing depend on the genotype?" It is logical to assume that a program designed to improve general vigor will probably produce stock that will tolerate more browsing, but experimental work will be needed to test this.

The potential benefits to wildlife from tree improvement are limited only by the imagination of the person considering them. Direct efforts could seek to increase the palatability of poor browse plants that are otherwise weed species. Selection for seed production should result in trees that will produce heavier crops of mast. If flowering dates are influenced by the genotype, mast crops could be insured by spreading out the period when different stocks are susceptible to frost damage. Efforts to breed hardier stock for planting on poor sites where drouth resistance, frost hardiness, and resistance to other unfavorable environmental factors is increased, will be watched carefully by game managers. Very often, the sites considered too poor for forest growth are the areas on which the game manager must work. Habitat improvement operations on farms would be made more effective if a wider choice of trees and shrubs were available that could thrive under these planting conditions and produce the type of cover needed. Low scrubby growth form and resistance to grazing, trampling and other disturbance would be sought for on this job.

Indirect benefits to wildlife from tree improvement would also be many. If breeding for disease resistance succeeds in saving chestnut from the chestnut blight, and the oaks from the oak wilt, many game species will eat better. These are just two examples; many could be found. Another indirect benefit to wildlife would accrue as a result of faster tree growth. Since less time would then be required for a tree to reach the necessary size, rotations and cutting cycles could be shortened, or a smaller area could supply the minimum volume needed for an economic cut with a given cutting cycle. This would increase the interspersion of age classes and improve conditions for wildlife. Time does not permit a more detailed listing of potential benefits.

Little factual knowledge is available on the subject of animal factors as they would influence the production of hardier trees. It is reasonable to assume that variations in genotypes within the species can result in reduced palatability, faster growth, and higher tolerance to browsing. If combined in a given stock, these qualities could reduce animal injury to the desired level.

The subject of wildlife benefits from tree improvement is a wide-open field for an active imagination, but even less is known about this subject than animal injury.

SITE FACTORS IN FOREST GENETICS RESEARCH

Stephen H. Spurr[1]

In this paper, I should like to re-emphasize what we all know but sometimes forget; namely, that hardiness as regards cold resistance is only one aspect of the adaptation of a plant to its environment. For a tree to survive and to thrive, it needs to be suited in all respects to its planting site. The air surrounding the tree is naturally an important element of this site, and the importance of the description of this air in terms of climatic factors can hardly be over-emphasized. On the other hand, we cannot forget that the roots of the tree are surrounded by soil from which comes most of the nutrition and water required for life. A species must be adapted to the soil fully as much as it must be adapted to the climate.

Our problem, then, is not really to develop hardier trees, for we have lots of species that are hardy under the most extreme climates of the Lake States. Rather, it is to develop races and species which will be adapted to the various sites needing afforestation in our region.

REQUIREMENTS FOR A GOOD FOREST TREE SPECIES

We may well begin by asking ourselves what sort of a tree do we want. The requirements are more or less obvious, but they may well be reiterated to point up the problem that faces us in Lake States tree breeding work.

First, of course, the species must be adapted to the climate. This means that the tree must be of such a genetic constitution that it is suited to the temperature range, seasons, annual rainfall and its seasonal pattern, day length, evaporation, and to all the other climatic factors characteristic of an area. As has already been pointed out, the basic problem in the Lake States is to develop coniferous species suitable for use in the southern half of the Lake States where native conifers are either lacking or where they thrive poorly. The problem of extending the range of a species south is much more complicated — and in the long run may prove to be more difficult — than that of finding a race that can be planted north of its natural range. In picking a species for its climatic adaptation, we cannot content ourselves merely with the regional climate, but we must also examine the microclimate. We are all aware of the danger of growing trees in frost pockets. Perhaps we are somewhat less aware of the fact that the characteristics of the local climate may change within a few feet in accordance with vegetation and topographic control. We must have species suitable not only for planting in a given region, but also for planting on a given topographic site in a given region.

Second, the species must be adapted to the soil and to the amount of moisture in that soil. In general, we know that certain species do best on limestone and other alkaline soils, whereas other species seem to prefer more acid soils. We are also aware of the general water

---

1/ Professor of Silviculture, School of Natural Resources, University of Michigan.

requirements of most species. A good deal has yet to be learned, however, concerning the relationship of the mineral composition of the soil and of the water in that soil to the growth of the various species of trees on it. In particular, we need to know the importance of genetic control in determining these ecological adaptations.

The above factors lie within the area of the present discussion. In passing, we may note, however, that there are other requirements for a good forest tree species. First of all, for growth on open sites, the species must be pioneer in successional status. It must be a tree suited for survival and growth in open exposed sites. Again, the tree must be resistant to insects and diseases. More often than not, lack of resistance of a given species varies to the degree that the tree is moved out from its optimal range. In this respect, resistance of a species to insects and diseases cannot be segregated from the adaptation of the same species to climate and soil. Finally, a good planting species must be of high economic value to justify the high cost of getting it established in the first place.

American foresters frequently talk about the wide variety of species available for forestry programs. Looking at the above list of qualifications for a good species, we should note how very few species meet these requirements for planting in the Lake States. Only two trees, red pine and jack pine, fulfill these specifications for any large part of our region. This is demonstrated by figures published in U.S.D.A. Technical Bulletin 1010, giving the cumulative number of trees planted by all public agencies, 1926-1944. In the three states of Michigan, Minnesota and Wisconsin, 84 percent of all the planting by public agencies consisted of these two species. Still another pine, white pine, accounted for an additional 9 percent. It is fairly obvious that our native pines have proved almost the sole acceptable large-scale planting species in the Lake States, having accounted for 93 percent of the planting by public agencies during this period. Most of the residual 7 percent was white spruce and miscellaneous conifers, with hardwoods accounting for less than 1 percent of the grand total.

Despite the figures given above, it is obvious that a wide range of sites and climatic zones occur in the Lake States. Red and jack pines are not suitable trees for all conditions. In general, all conifers have been planted too far south of their native range. The many difficulties arising from insects and disease, together with purely climatic difficulties, testify to the need for conifers suitable to the sites and climates of the southern half of the Lake States. To some extent, this need may be met by isolating ecotypes of existing conifers suitable for planting under these conditions. In the long run, however, reliance must inevitably be placed either on exotics or on hybrids carefully bred for suitability to these planting conditions. Where satisfactory native species do not exist, the only recourses are to bring in trees from afar or to develop new trees.

At the same time, we must not forget the possibility of hardwood culture. The almost universal failures of our hardwood plantings are not attributable in most cases to lack of climatic adaptation. Rather, they are due to lack of knowledge of proper cultural techniques coupled with failure to protect the hardwoods against browsing by deer, rabbits, and other animals. We now know that most of our hardwoods are not trees that can be stuck into a piece of low-grade denuded land, and left to their own devices with any chance of success. If we wish to culture hardwoods successfully, we must borrow technical knowledge from the horticulturist rather than from the silviculturist trained solely in the handling of coniferous stock. Generations of experience in growing fruit and nut trees and other arboricultural crops point the way to proper hardwood timber culture. We must plant our hardwoods on good sites, cultivate them for several years after planting, and in general, give them care and attention throughout their life. If we have the right species and the right site, it is wholly possible that such intensive culture may well prove economic, at least in years to come. At any rate, most of our hardwoods are not species for poor planting sites. Practically all of the Lake States contain valuable endemic hardwood species. The possibility of isolating high-grade hardwoods suitable for specific climatic zones and for specific soil types should not be neglected by the forest geneticist and the silviculturist.

RESEARCH NEEDED

The purpose of the above discussion is not to summarize the literature or to present anything new to the geneticist and silviculturist in the Lake States region. Rather, by emphasizing well-known facts, it is intended to point out that we have a very real problem here in the Lake States in isolating and identifying strains of trees suitable to our various climatic zones, soils, and topographic locations. Furthermore, we are so limited in our satisfactory species as to be able to use a wide variety of improved strains and hybrids when they become available.

In dealing with the problem of site adaptation, we enter a realm where cooperative research between the forest geneticist and the ecologist is essential. It is not sufficient merely to isolate a new race or species. Neither is it satisfactory to determine what local and native plants thrive best on a particular site. The only solution is to achieve a better understanding of interactions between genetic control and environmental adaptation. A given strain, variety or species may be worthless under one condition and highly valuable in another environment. Mass selection techniques will never be a satisfactory answer to this problem. Too many possible genetic combinations, climatic situations, and soil conditions exist to permit testing them by purely empirical mass-selection studies.

The only answer, therefore, is fundamental research designed to develop an understanding of the interrelationships between a tree's genetic makeup and its adaptation to environmental conditions.

For any site needing forest establishment, we must know first how to recognize what sort of forest tree is required. Second, we must know where to go to look for such a tree. Third, in the event that we do not find it in nature, we must then know how to breed it. If possible, we should derive such a new strain within our naturally occurring species, this is, by relying on intraspecific breeding. In the event that no present species are suitable, we must then be able to set out and derive a hybrid that will meet our requirements. Then, and only then, can we fit the tree to the site. Then, and only then, will we be able to establish good forest stands wherever they are needed.

LESSONS OF THE PAST

Scott S. Pauley[1]

In the present state of our knowledge, it is probably somewhat premature, and certainly presumptuous, for anyone to make far-reaching decisions as to what should be, and what should not be, incorporated in forest tree improvement plans for any particular locality. Nevertheless, past experiences in the application of genetics in forestry, both in this country and abroad, point up certain promising courses of action, as well as pitfalls that may be avoided.

For convenience, such lessons of the past may be grouped in two general categories:

1. Those which might be termed "public relations" problems.

2. Those of a more technical nature.

The first lesson of a public relations nature is concerned with what the cigarette advertisers call "extravagant claims." I grant that a reasonable amount of promotion may be justified in securing recognition for the new application of a science. Certainly as a means of gaining financial support, the public, and especially prospective donors, must be informed of the advantages that may accrue from research in a new field. Unfortunately, however, the emphasis may frequently be so unbalanced that a completely erroneous impression is created in the minds of the uninformed. The sad consequence may be that if the promised results are not immediately forthcoming, financial support may be lost, and the whole program discarded.

I would venture to say that the average citizen, and even many foresters, if asked what was being done in the application of genetics in forestry would unhesitatingly say, "O yes! They're creating those fast-growing superhybrids."

1/ Lecturer in Genetics, Cabot Foundation, Harvard University.

The fact that such mundane activities as the selection and progeny testing of wild genotypes and the development of seed certification systems are at present the chief concerns of most forest genetic programs is frequently given secondary billing. But since it is to these rather unglamorous applications of genetics in forestry that we may look for early results in tree improvement, there seems to be little point in keeping them under cover.

I do not wish, by these remarks, to discredit in any way the valuable studies in controlled intra- and interspecific hybridization now carried on by many workers in this country and abroad. I have no doubt but that such work will ultimately be richly productive. But I do feel we must discourage the popular prevailing misconception that the end of all forest tree improvement entails the indiscriminate production of F_1 hybrids.

Another lesson that we may note from a study of past efforts to apply genetics in forestry also falls in the public relations field. I refer to the unfortunate relationship that has existed, and still exists in some quarters, between what might be called the "classical" silviculturist and the forest geneticist.

The principal area of misunderstanding appears to be centered about the old "nature vs. nurture" or "genotype vs. environment" argument. Although a popular biological bone of contention in the early part of this century, this argument was soon recognized as futile and did not long persist, except, apparently, in the field of forestry. There appear to be several contributing causes. One is that silviculture has developed under a strong environmentalist influence, and there has thus been a reluctance to acknowledge such heretical modern concepts as the genotype and the phenotype. The geneticists themselves have frequently aided little in efforts to attain a meeting of minds. We still, for example, speak glibly of "environmental variation" in contrast to "genetic variation" as if they were quite independent phenomena.

Fortunately, such fundamental misunderstandings are fast disappearing; and with the eventual incorporation of forest genetics in forestry school curricula, they will, I am sure, completely disappear.

Of those lessons concerned with the more technical aspects of tree improvement, the first I would like to mention is of a somewhat general nature: the venerable problem of "pure," "fundamental," or "basic" vs. "applied" research.

The question here, as in the case of the "genotype vs. environment" argument is not one of relative merit. Both are certainly necessary. The trouble lies in the fact that the practical cart is frequently placed far in advance of the fundamental horse. The tendency to such manipulation is common in other fields of science, but I am personally doubtful if the results are quite as serious in forest genetics as some people believe.

I think almost everyone would agree that the most desirable plan for a tree improvement program in the Lake States would be to place principal emphasis on basic genetical, physiological, and other allied fields of research for the next 50 years. At the end of that time we would be in a much better position to devise a tree improvement program.

Such a procedure is obviously impossible, and in many respects undesirable. In the first place, there simply aren't enough altruistic millionaires available. Basic and applied research can, I think, very advantageously share the same bed; but some caution should be exercised to prevent the basic studies from being pushed too near the edge. In my opinion, one of the conspicuous shortcomings of several tree improvement programs, both in this country and abroad, has been the almost complete neglect of studies concerned with wild intraspecific diversity. This neglect is probably traceable in large part to a persistence of the environmentalist concept of intraspecific genetic uniformity. Certainly such basic studies are a necessary prerequisite for any improvement program.

Deliberation on the relative emphasis to be placed on basic, as opposed to applied, research leads quite naturally to the contemplation of the desirable over-all plan of a tree improvement program for any particular region. My considered opinion is that one of the most important lessons to be gained from a study of European and domestic experience is the desirability of placing initial emphasis on an extensive, rather than an intensive, approach to tree improvement problems — on what many people insist upon calling "basic" studies of intraspecific variation. Although such studies of intraspecific diversity — the "reaction range" of genotypes, etc. — are technically of a basic nature, they may, nevertheless, be rapidly and richly productive of important practical results.

Provenance studies, for example, which have been of such fundamental practical significance in the definition of racial diversity in pine and spruce in Europe, should unquestionably be given high priority in any proposed improvement program for species native to the Lake States.

In conjunction with such efforts to improve the genetical quality of seed on a geographic basis, attention should also be directed to the isolation of genetically superior local seed sources, both stands and individual trees. Such studies will require progeny testing on a large scale; but in areas where planting is now being done, the added costs of such tests should not be prohibitive. Actual seed costs will, of course, be somewhat increased, as will also the clerical expense of keeping adequate records. With careful planning, the requirements of a statistically sound experimental design will not add greatly to the usual planting costs.

Together with such selection and testing efforts, a major portion of initial research activity should be directed to methods of insuring regular and adequate seed production from selected stands or individuals.

Although essentially a physiological problem, as is also the important problem of seed storage, its early solution is just as essential as is that of the strictly genetical phases of the improvement program.

In those programs designed to improve Lake States conifers, I believe that major emphasis for perhaps the next 50 years should be centered on the isolation of the best wild seed sources and on methods of insuring sufficient seed production to meet planting needs. I do not wish to imply, however, that intensive breeding studies should not, in special cases, be pursued. Studies concerned with disease and insect resistance and other specific improvement problems should be encouraged and supported in conjunction with the more extensive phases of the program.

There is one final lesson that I think should now be apparent. I have touched briefly on the matter before in connection with the still frequent misunderstandings that persist between some silviculturists and forest geneticists. This lesson is simply that so-called genetical research is actually, in large measure, so-called silvical research. For some odd reason we still insist upon separating the two. For other odd reasons many foresters are reluctant to admit that genetical research can in any way contribute to the development of sound silvicultural management plans in the self-produced forest.

When we realize that the great majority of the forests of this country are at present, and will doubtless long continue to be, managed under systems of self-reproduction, we must make the altogether reasonable inference that if their genetic quality is to be improved, or even maintained, we must eventually come to recognize the necessity for learning considerably more about their hereditary characteristics. I think it is a matter of little consequence whether such knowledge is labeled "genetical" or "silvical," or whether it is accumulated by self-styled "forest geneticists" or "silviculturists." I feel very strongly that one of the principal and unavoidable responsibilities of forest geneticists is to contribute to this knowledge.

THE FOREST GENETICS RESEARCH FOUNDATION

Ernest B. Babcock 1/

To begin with, I want to distinguish clearly between the Foundation that I represent and the Institute of Forest Genetics at Placerville, California. The Institute was founded many years ago by James G. Eddy of Seattle and I have served on its advisory board. In recent years he and I and a few others found that the Institute was not

1/ Executive Vice-President, Forest Genetics Research Foundation.

adequately financed to enable it to function as a progressive center of research in forest genetics. This problem set us thinking and, later on, we decided to organize a foundation for the purpose of supporting research in this field. This Foundation was incorporated in April 1951 and received certification of exemption from federal taxes in April 1952.

The main objectives of the Foundation are: (1) to receive and distribute financial support for research in forest genetics, especially for fundamental research; (2) to stimulate and assist in public education concerning the need for and importance of such research. Three types of gifts are accepted by the Foundation: (1) contributions to the general fund which can be used for either maintenance or research; (2) contributions to a permanent endowment fund; and (3) contributions for specified projects.

The Foundation has sufficient in the general fund to continue operations but has not received enough to permit the making of any grants. One small contribution for the permanent endowment has been received. Two contributions, totaling $20,000, have been accepted for a specified project. Thus far no support has come from any industrial firms; but it is hoped that eventually this source of support for research will provide an important part of the funds administered by the Foundation.

The project now being supported by the $20,000 contributed by an individual is a west-wide survey of ponderosa pine. Its primary purpose is to bring together in living condition as many as possible of the phenotypic differences existing in this species so that they may be subjected to a genetic analysis. The long-range aim is the synthetic breeding of super-ponderosa types.

When the Foundation succeeds in bringing the general fund up to a point where something can be allocated for the support of research, there are various ways in which such assistance can be extended. (1) Grants can be made either to individual scientists or to institutions. (2) Scholarships for graduate students and fellowships for post-doctorate researches can be awarded. An important policy of the Foundation is that it will seek the advice and cooperation of appropriate regional committees or groups in reaching decisions about acceptance of grants for specified projects, the making of grants, and awarding of scholarships or fellowships.

In closing these remarks permit, if you please, a few words about forest genetics and conservation. One of the most urgent needs of American forestry today, it seems to me, is more emphasis on the importance of heredity in forest conservation. My recent paper on "Future Forests and Heredity" was concluded as follows:

"In the hope that they may serve as a basis for discussion in any future conferences on natural resources, I wish to submit the following theses:

"1. The preservation of the better and elimination of the poorer hereditary stocks in each important timber tree species must be recognized as a basic principle in forest conservation.

"2. The utilization of the best available hereditary traits or features of each important species, i.e., conservation of superior genes, in the creation of ideal types of timber trees by means of applied genetics must be recognized as a basic principle of forest conservation.

"3. Since the utilization of superior genetic stocks of timber trees in growing our future forests can be accomplished only by qualified scientists, working intensively, continuously and cooperatively for many years, the adequate financial support of research in forest genetics and allied disciplines is of basic importance in forest conservation."

(Ed. note: The above three theses, at Dr. Babcock's suggestion, were incorporated in the resolutions adopted by the Conference.)

IMPORTANCE OF SEED SOURCE AND THE NEED OF TREE SEED FARMS*

J. H. Stoeckeler[1]

Most foresters in the Lake States are convinced that as a general rule, our native or near-native species are best adapted for large-scale reforestation, using seed sources fairly close to the planting site. Also there is general agreement that seed should come from trees of good form and vigor.

There are already a number of experiments and observations in the Lake States which highlight the importance of using our native species rather than exotics.

Also from numerous European observations on provenience tests, we have rather excellent guides which should be able to steer us in our collection of seed, pending the maturation of our own provenience tests.

Let us review briefly some of these observations and experiences, in Europe as well as in the United States.

RESULTS OF PAST EXPERIENCE

The results of past experience in northern Europe indicate that tree seed should generally be planted within a zone varying by not more than 1° C. (almost 2° F.) during the growing season from that of the original

1/ Forester, Northern Lakes Branch, Lake States Forest Experiment Station.

habitat of the trees. In terms of latitude it means moving seed not more than about 90 to 150 miles from its original habitat, nor more than about 100 to 200 yards in elevation. In some cases the maximum is set at 380 yards.

European experience has also been that cheap seed collected from low, bushy trees, easy to collect from, especially from rather distant sources, is a rather poor investment.

In our own experience in Wisconsin, we have had rather poor results with exotics, particularly with Scotch pine, and to a lesser extent with Norway spruce (Stoeckeler and Rudolf 1949). The poor results with the former species makes one rather dubious about broadening the program of planting Scotch pine for Christmas trees. Red pine on the other hand is a perfectly good Christmas tree. Those that escape marketing for Christmas trees, would seem rather sure to grow into good stands of high value, clean-boled pulpwood or sawlogs.

One of the early advocates of a better tree seed program in the Lake States was C. G. Bates (1927) who suggested certification of seed, and the setting aside of tree seed farms (Bates 1928) of the best natural and planted stands for future seed collection. He suggested progeny tests to verify the value of the various geographic strains.

Subsequently, Baldwin and Shirley (1936) proposed a forest seed program for the U.S.

Results of provenience tests in Minnesota on red pine (Rudolf 1947) would seem to bear out the need for a seed certification program. Its urgency is accentuated by the need of reforesting as much as 10 or 12 million acres of idle or semi-productive land (Rudolf 1950) in the Lake States.

In 1952, 24 state, federal, and soil conservation districts in the three Lake States produced a total of 67.6 million trees (Forest Service 1952). The total acreage planted in the three states in the three states in the one-year period ending June 1952 is reported as 69,030, including all classes of land ownership.

THE U.S.D.A. SEED POLICY OF 1939

Until more precise information is available, it would be well to consider the adoption or adaptation of the general principles in the U.S.D.A. Seed Policy of 1939. In brief, this policy recommends use of seed of known origin from within 100 miles or 1,000 feet in elevation of the planting site (U.S.D.A. 1939).

HOW GOOD IS THE PRESENT CONTROL OF SEED SOURCE?

The past policy in seed collection to meet the demands of the huge planting program generally has been to purchase cones in the open

market. No doubt, the bulk of the seed for the plantings made in each of the Lake States originates within the state. Also a fairly good proportion of the seedlings produced from it probably are planted within 100 miles of the source as recommended (to conform in a fashion to the limit stated) in the U.S.D.A. seed policy. But there is virtually no control over the quality of stands the seed or cones come from, and even less over the type of individual trees from which they are collected.

PROPOSED TREE SEED FARMS

The current lack of reasonably close control over the origin of seed should cause serious consideration of the establishment of tree seed farms. Eventually in the course of three or four decades, we may perhaps have a start on the planting of a considerable acreage of tree seed orchards, all of which are progeny of elite parent trees selected by tree breeders.

Tree seed farms, as I consider them, are areas of the best existing natural or planted trees of known origin, at least 10 acres in size 2/ and with trees at least one-third to one-half of full maturity, but preferably older. In the stand as a whole, the trees ought to be of good form, generally free from appreciable insect or disease infestation, and of good growth rate and vigor.

Such tree seed farms should probably be located about 800 feet away from stands of the same species, which are inferior in form or growth rate, to minimize cross-pollination. The distance could perhaps be reduced if the tree breeders find adequate evidence that it would be safe to do so.

It would be desirable in commercial (non-commercial, if necessary) thinning operations to rogue out the trees which are crooked, wolfish, heavy-limbed, forked, diseased, and perhaps insect infested.

There should be records of these selected stands, giving accurate information as to location, ownership, tree species, age, size and quality of trees, and other pertinent facts.

Tracts that have been obviously "high-graded" or stripped of their better growing stock should be avoided.

Outstanding planted stands of native species could be admitted as tree seed farms providing geographic origin were rather definitely established, the trees were of good form and growth rate, and the stand were at least one-third of rotation age.

Local plantations of exotics to be used as seed sources for the production of long-range crops like pulpwood, veneer, or sawlogs, would have to meet the same rigid restrictions as for planted native species, and

---

2/ A lesser acreage could be permitted for desirable exotics.

we might consider adding the proviso that the stand must show considerable ability to regenerate naturally.

Minimum ages for various species to qualify as tree seed farms are tentatively suggested as 25 years for jack pine and 40 years for red pine, white pine, white spruce, and black spruce. By that time, tendencies toward poor climatic adaptability may have shown up, as well as undesirable traits such as crookedness of central stem, heavy limbs, and susceptibility to disease and insects.

The need of tree seed farms seems to be most urgent for red pine, jack pine, white spruce, white pine, and black spruce, in the order named. As we learn more about successful regeneration of hardwoods, red oak, yellow birch, basswood, and sugar maple are certain to be added to the list.

Besides cultural measures, such as thinning, to promote good growth of trees, I can readily visualize the eventual use of fertilizers applied in tailor-made dosages to selected stands to encourage seed production.

Tree seed farms should be set up in tracts with comparatively good stability of land ownership, and where there is an avowed intention for continuity of the tract for this purpose. Stands in state forests, county forests, national forests, and industrial forests would seem to be especially suited for tree seed farms. Certain exceptionally fine privately-owned stands, notably on large estates and those held for recreational purposes, might also be satisfactory as tree seed farms. Individual smaller tracts such as farm woodlots might qualify providing authorities could convince the landowner of the value of the tract as a seed tree farm, and offer some type of inducement, financial and otherwise, to treat the stand as such.

PROPOSED SEED COLLECTION ZONES

Seed from the tree seed farms would have to be certified, if not standwise, at least to the extent of a county or other zonal designation for it, so nursery sowings could be kept separately. For the more immediate future the best that probably can be hoped for is to divide each state into three or four broad zones for seed collection. Such zones could be developed from those tentatively set up for red pine (Rudolf 1947) or they might be derived from climatic maps (U.S.D.A. 1941).

As a further study is made, a finer subdivision may be warranted, for example, in areas near the Great Lakes where in a distance of around 40 miles there is as much as 30 to 40 days' difference in the frost-free period.

Open market purchases of cones could be rather readily segregated into these zones. Seed from the extractories could be kept separate by zones and used for nursery seeding and distribution to tree planters in that

zone. [3] Complete adherence to the proposed zoning scheme may not be feasible in the near future, but still a high percent of the trees would then be planted in a climatic belt varying not more than 1° or 2° C. (approx. 2 to 4° F.) from the site of the parent trees.

Some seed from northern zones will, of necessity, have to be moved to the more southerly zones, because of the virtual absence of the spruces and good quality red pine there.

SUGGESTED METHODS OF IMPROVING CONTROL OF SEED SOURCE

In the meantime, even before seed tree farms are set up, we can obtain some control of the type of stands and trees from which cones come, as follows:

1. A method which has been used is to have pickers follow behind a logging operation during the period of seed ripening, and to have a forester or trainee designate the individual felled trees from which cones may be picked.

2. In some instances an agreement can be made to fell selected trees or cut out the tops of heavily laden spruce or fir trees during the period of seed ripeness, several months in advance of the regular logging operation, using cutting and picking crews hired by the landowner.

3. Another method involves hiring crews to pick cones or seed, under supervision, from selected stands or even from designated trees within selected stands. Payment could be made on a per-bushel or other unit of measure basis, so as to provide production incentives.

4. A fourth method is to contract the picking of cones from selected stands with the small forest landowner or reliable commercial seed dealers. This might include some cones from squirrel cuttings and squirrel caches.

Any of the four above methods would be superior to open market purchase of uncertified cones or seed. The seed would, no doubt, be somewhat more expensive but cost of seed is a small factor in the overall cost of production of trees. For instance, a pound of red pine seed currently costing $12.50 per pound will produce about 25 thousand 2-2 transplants, which sell at $20 per thousand. The seed cost is then only 50¢ per thousand trees produced, or 2.5 percent of the production cost. Even if the cost of seed were doubled by exercising more control of its collection, the cost of stock would be raised only a little.

---

[3] The Forest Service in the Lake States, in effect, has done this for quite a period of years, keeping collections separate by national forests, and as much as possible planting the trees produced on the forest where collected.

An educational program is needed among commercial cone collectors and those extracting such cones, to put across the idea of more care in selection of stands and trees from which to pick cones. Prospective purchasers of certified seed also need to be convinced that a premium price is warranted for select seed of known origin.

LITERATURE CITED

Baldwin, Henry I., and Shirley, Hardy L.
1936. Forest seed control. Jour. For. 34(7&8), July and August.

Bates, C. G.
1927. Better seeds, better trees. Jour. For. 25(2): 130-144. illus.

______ 1928. "Tree seed farms." Jour. For. 26(7): 969-976.

Rudolf, Paul O.
1950. Forest plantations in the Lake States. USDA Tech. Bull. No. 1010, 171 pp., illus.

______ 1947. Importance of red pine seed source. Proc. S.A.F. meeting 1947: 384-398.

Stoeckeler, J. H., and Rudolf, Paul O.
1949. Winter injury and recovery of conifers in the upper midwest. LSFES, Sta. Paper No. 18, 20 pp., mimeo.

U. S. Department of Agriculture
1939. U. S. Dept. Agriculture Forest Seed Policy of May 16, 1939. Circular letter, 3 pp. (S-PLANTING, Seed, Department Seed Policy). July 20.

______ 1941. Climate and man. Yearbook of Agriculture. 1248 pp., illus.

U. S. Forest Service
1948. Tree breeding at the Institute of Forest Genetics. USDA Misc. Publ. 659, 14 pp., illus.

______ 1952. Forest and shelterbelt planting in the U.S. Report. 4 pp. processed.

______ 1952. Forest tree nurseries. Tree Planters' Notes, No. 13, 24 pp., processed. Jan.

DISCUSSION

During the conference there was a considerable amount of discussion on almost every paper. Following are some items of interest brought out in the discussion and not elsewhere covered in the Proceedings:

1. European studies have shown that self-pollinated Scotch pines produced less seed and less vigorous stock than those which were cross-pollinated. Some observations on red pine in Lower Michigan indicate that self-pollination results in reduced seed production.

2. Longevity of pine pollen depends on relative humidity and temperature. With these under proper control, pine pollen can be stored for a year or more.

3. The distance to which viable pine pollen may be dispersed depends upon wind velocity, topography, and other factors, but usually is not over 300 feet and seldom over 700 feet.

4. Hybrid stock usually can be distinguished in nursery seedbeds. This makes it practical to develop seed production farms in which different species can be planted so that they will cross-pollinate each other. The seed can then be sown in the nursery and the hybrids sorted at the time of lifting. Other than hybrids, however, it may not be feasible to make genetic selections in the seedbed.

5. Weevil-free eastern white pines have been found in stands where weevil damage is severe. These are trees with thin shoots. Material from these trees is being grafted on to badly-weeviled orchard-type trees to test their resistance to weevil attack.

6. The Consolidated Water Power and Paper Company obtains their spruce seed from designated trees which are then felled during logging operations, usually within 50 to 75 miles of the planting site.

7. There is a real need for more research in seed production.

8. Present cutting practices in aspen may be favoring inferior growing stock by leaving smaller trees.

9. Foresters need some easily interpreted guides for recognizing superior trees in the field.

10. Insects and diseases often limit the extent to which trees can be introduced into new areas. Sometimes trees relatively resistant to insects and diseases in youth may lose their resistance as they grow older.

FOREST GENETICS CONFERENCE
at
Trees for Tomorrow Conservation Camp
Eagle River, Wisconsin
March 30 - April 1, 1953

The Conference unanimously adopted the following recommendations of the resolutions committee:

1. That there be established a Lake States Forest Tree Improvement Committee for the purpose of encouraging and coordinating forest genetics activities in this region. That a nominating committee, consisting of Messrs. M. B. Dickerman, R. A. Brink, E. J. Adams, and J. B. Millar, appoint a 6- to 10-man tree improvement committee representative of the interested agencies, geographical areas, and subject matter interests in the region.

2. That the tree improvement committee continue annual or periodic meetings such as the present Lake States Forest Genetics Conference.

3. That the tree improvement committee, as one of its first activities, take steps to foster forest tree seed certification in the three Lake States.

4. That appreciation be extended to the Lake States Forest Experiment Station for their efforts in organizing this meeting and to Trees for Tomorrow for providing these facilities.

In addition, the Conference gave unanimous endorsement of the following three theses submitted by Dr. Ernest S. Babcock of the Forest Genetics Research Foundation:

1. The preservation of the better and elimination of the poorer hereditary stocks in each important timber tree species must be recognized as a basic principle in forest conservation.

2. The utilization of the best available hereditary traits or features of each important species, i.e., conservation of superior genes, in the creation of ideal types of timber trees by means of applied genetics must be recognized as a basic principle of forest conservation.

3. Since the utilization of superior genetic stocks of timber trees in growing our future forests can be accomplished only by qualified scientists, working intensively, continuously and cooperatively for many years, the adequate financial support of research in forest genetics and allied disciplines is of basic importance in forest conservation.

RESOLUTIONS COMMITTEE

D. P. Duncan	P. O. Rudolf
R. G. Hitt	S. H. Spurr
S. S. Pauley	R. J. Wood

ATTENDANCE AT FOREST GENETICS CONFERENCE

Trees for Tomorrow Conservation Camp
Eagle River, Wisconsin
March 31 - April 1, 1953

Forest Industries

Robert M. Kolbe	Connor Lumber & Land Co., Laona, Wis.
E. S. Hurd	Consolidated Water Power & Paper Co., Rhinelander, Wis.
J. W. Macon	Do.
E. B. Hurst	Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
Raymond J. Wood	Diamond Match Co., Cloquet, Minn.
Leland W. Stratton	Escanaba Paper Co., Escanaba, Mich.
Willis M. Van Horn	Institute of Paper Chemistry, Appleton, Wis.
L. Ernest George	Kimberly-Clark Corporation, Neenah, Wis.
J. B. Millar	Do.
R. E. Burke	Marathon Corporation, Rothschild, Wis.
Charles A. Mueller	Do.
B. L. Berklund	Nekoosa-Edwards Paper Co., Port Edwards, Wis.
Robert C. Dosen	Do.
M. N. Taylor	Trees for Tomorrow, Inc., Merrill, Wis.

Colleges and Universities

R. A. Brink	Dept. of Genetics, University of Wisconsin, Madison, Wis.
Robert G. Hitt	Do.
Charles E. Olson	Do.
James E. Kuntz	Dept. of Plant Pathology, University of Wisconsin, Madison, Wis.
Robert F. Patton	Do.
A. J. Riker	Do.
Keith R. Shea	Do.
Philip N. Joranson	Dept. of Biology, Beloit College, Beloit, Wis.
S. A. Graham	Dept. of Forestry, School of Natural Resources, University of Michigan, Ann Arbor, Mich.
Stephen H. Spurr	Do.
P. W. Robbins	Dept. of Forestry, Michigan State College, East Lansing, Mich.
D. P. Duncan	School of Forestry, University of Minnesota, St. Paul, Minn.
R. A. Jensen	Forest Experiment Station, University of Minnesota, Cloquet, Minn.
T. Schantz-Hansen	Do.
D. W. French	Dept. of Plant Pathology, University of Minnesota, St. Paul, Minn.
Scott S. Pauley	Cabot Foundation, Harvard University, Petersham, Mass.

State Conservation Departments

John A. Beale	Wisconsin Conservation Dept., Wisconsin Rapids, Wis.
Norbert B. Underwood	Wisconsin Conservation Dept., Madison, Wis.
Frank D. Irving, Jr.	Game Management Division, Wisconsin Conservation Dept., Antigo, Wis.
F. J. Hodge	Forestry Division, Michigan Dept. of Conservation, Lansing, Mich.
Earl J. Adams	Division of Forestry, Minnesota Dept. of Conservation, St. Paul, Minn.
Bernard M. Granum	Iron Range Resources & Rehabilitation, Hibbing, Minn.

U. S. Forest Service

Benson H. Paul	Forest Products Laboratory, Madison, Wis.
G. A. Limstrom	Central States Forest Experiment Station, Columbus, Ohio
L. P. Neff	Region 9, Milwaukee, Wis.
H. E. Ochsner	Do.
M. B. Dickerman	Lake States Forest Experiment Station, St. Paul, Minn.
R. D. McCulley	Do.
Paul O. Rudolf	Do.
Z. A. Zasada	Lake States Forest Experiment Station, Grand Rapids, Minn.
H. F. Scholz	Lake States Forest Experiment Station, Rhinelander, Wis.
J. H. Stoeckeler	Do.
Carl Arbogast, Jr.	Lake States Forest Experiment Station, Marquette, Mich.

U. S. Office of Indian Affairs

S. C. Carey	Red Lake, Minn.
C. T. Eggen	Neopit, Wis.
William Heritage	Minneapolis, Minn.
Charles H. Racey	Ashland, Wis.

U. S. Bureau of Entomology & Plant Quarantine

H. J. MacAloney	Forest Insect Laboratory, Milwaukee, Wis.
Ray Weber	Blister Rust Control, Antigo, Wis.

Other

Ernest B. Babcock	Forest Genetics Research Foundation, Berkeley 4, Calif.
Lewis C. French	Milwaukee Journal, Milwaukee, Wis.
Allan S. Haukom	Wisconsin Forestry Advisory Committee, Madison, Wis.
C. C. Heimburger	Southern Experiment Station, Ontario Dept. of Lands & Forests, Maple, Ont., Canada